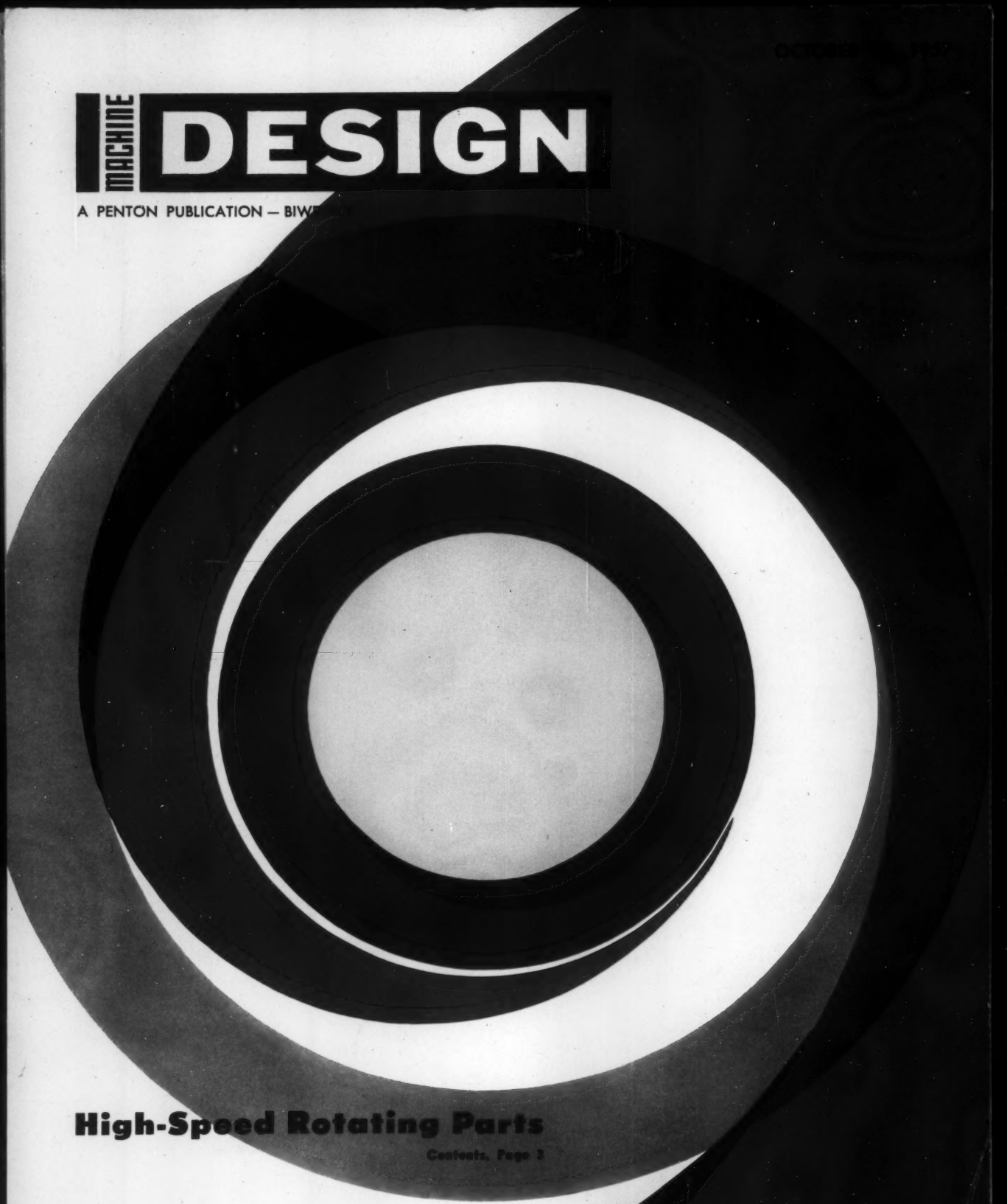
MACHINE DESIGN

A PENTON PUBLICATION — BIW



High-Speed Rotating Parts

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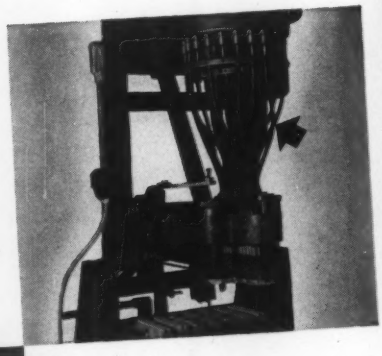
FARNSWORTH

S.S.White Flexible Shafts Step Up Design Efficiency

The manufacturer of this multiple spindle drill press finds that S.S. WHITE FLEXIBLE SHAFTS allow a wide range of positions for different drilling jobs.

This is only one example of the versatility . . . efficiency . . . and freedom S.S. WHITE FLEXIBLE SHAFTS are bringing to hundreds of industrial designs. The restrictions imposed by rigid shafting are eliminated. With flexible shafts you position power sources . . . driven members . . . controlled parts to better advantage. By simplifying methods of connection and adapting, costs can be reduced. Assembly is cheaper . . . alignment problems are eliminated . . . and product efficiency is often greatly improved!

Consider your own product. Chances are, S.S. WHITE FLEXIBLE SHAFTS are the simple, economical answer to your power drive and control problems. S.S. WHITE FLEXIBLE SHAFTS are noted for quality, performance and dependability. For more information and expert assistance in selecting and applying an S.S. WHITE flexible shaft to your product, just write to



S.S.White

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S. S. White Industrial Division, Dept. 4, 10 East 40th St., New York 16, N. Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

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Ross-Skyline

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Any Skyline Head Attaches to Any Skyline Valve Body

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Now the JIC spool solenoid valves join the Ross Skyline. Now six actuating heads and seven in-line and base mounted bodies—all completely interchangeable—give you any valve you want in this series designed especially to last millions more cycles than ordinary valves. But, these quality valves come to you at *sensible* prices! For instance, the 3/8" Silvermodel base mounted, 4-way is only $62.50 complete, and complies with all JIC requirements. Write for bulletin 315.

Ross OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVENUE • DETROIT 3, MICHIGAN

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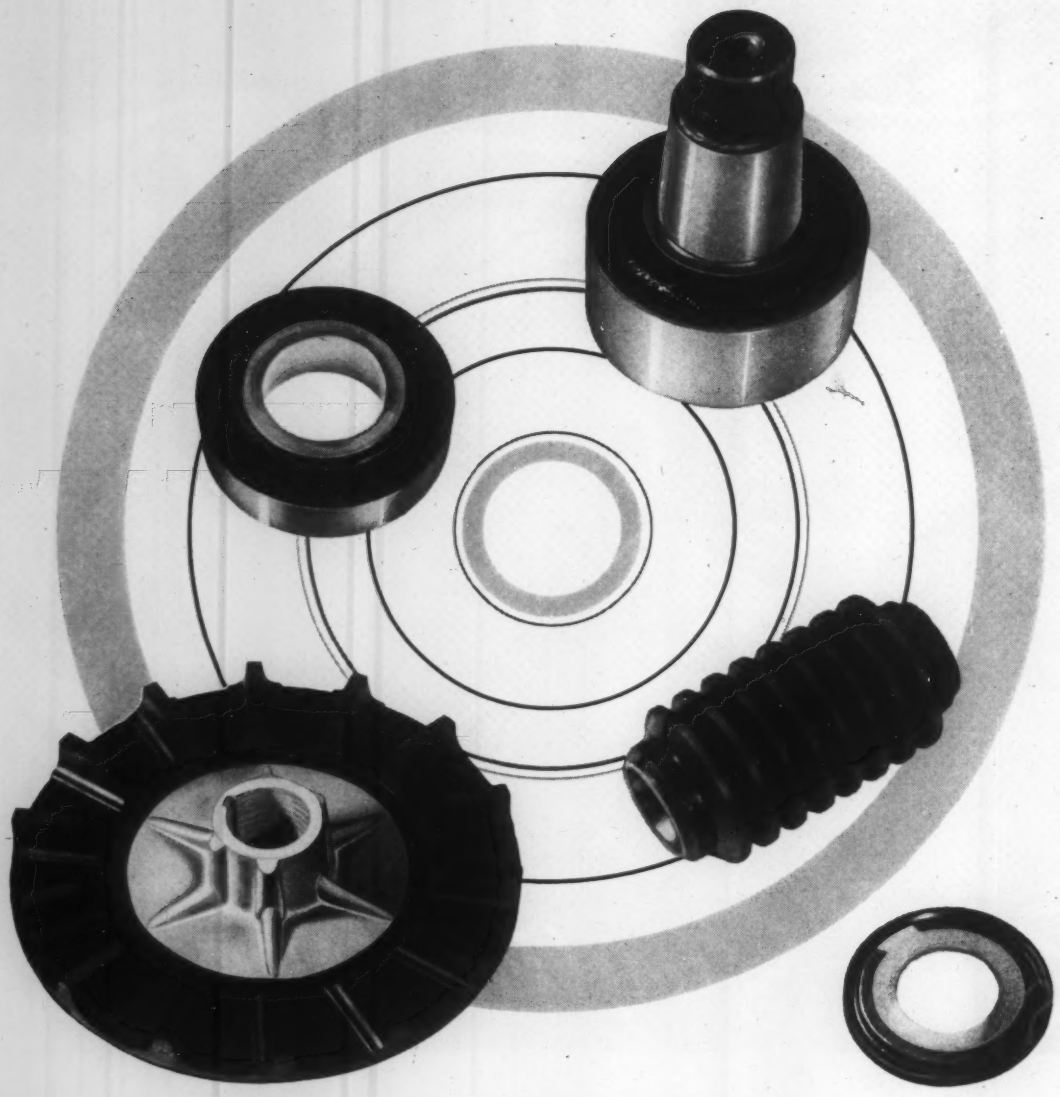

Bonds beyond the usual bounds

Bonding rubber to metal was long a bugaboo to both manufacturers and users of many molded rubber parts. But today, at Goodyear, it's a problem of the past.

Originally, production methods of obtaining adhesion centered around a very limited group of metals and rubber compounds. But, over the years, the molded rubber specialists of Goodyear perfected new techniques of bonding which opened entirely new fields for the use of rubber by design engineers.

Unmatched rubber-to-metal bonding is just one of the advantages of working with Goodyear on molded or extruded rubber goods. Other reasons are outstanding product design assistance, rubber compounding, mold design and the latest in production methods and equipment plus the expert help of the G.T.M.—Goodyear Technical Man. For full details write to Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

MOLDED GOODS by

GOODYEAR

THE GREATEST NAME IN RUBBER

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October 17, 1957 Volume 29—No. 21

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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Handles for the gold-plated (left) and standard "Heavy" (center) Gillette safety razors are made from Anaconda leaded commercial bronze special-shape seamless tube, .4525″ O.D., .371″ I.D. "Regular" model (right) is of commercial bronze .395″ O.D., .324″ I.D.

Gillette shaves costs with Anaconda special-shape tubes

The problem: The Gillette Safety Razor Company, Boston, Mass., formerly used drawn shells for the handles of its famous line of razors. Press-fit assembly of components called for very close tolerances and suppliers of the drawn shell had difficulty in controlling the dimensions to the accuracy required. Rejects and production delays were becoming a costly problem to Gillette, and there was also excessive waste of material in trimming the shells after the knurling, grooving and rolling operations.

The solution: American Brass Company representatives suggested the use of special-shape (fluted) tubes to meet the tolerances required—in alloys suitable for the machining operations. Gillette tried the idea and now uses Anaconda special-shape tubes for handles of three models.

Long lengths of the tube are fed into high-speed, multiple-spindle machines which automatically convert the tube to razor handles ready for the plating room. Production is greatly increased, rejects and waste material are reduced to a minimum, and the uniformity of the handles simplifies assembly. Most important of all to the Gillette Safety Razor Company is the improved quality of the finished product.

Save Material and Production Costs: Special-shape seamless tubes—of copper, copper alloys or aluminum—in standard lengths, or cut to specified lengths, can save several steps in arriving at a finished product. The American Brass Company's French Small Tube Division are specialists in producing small tubes (up to ¾″ O.D.) of special design and, in addition to maintaining a wide range of stock dies, are ready to cooperate fully in the development of new shapes to meet specific requirements.

For Action: Contact our nearest District Sales Office or send a sample, drawing or description, estimated quantity, kind of metal required and other pertinent data to: The American Brass Company, French Small Tube Division, Waterbury 20, Conn.

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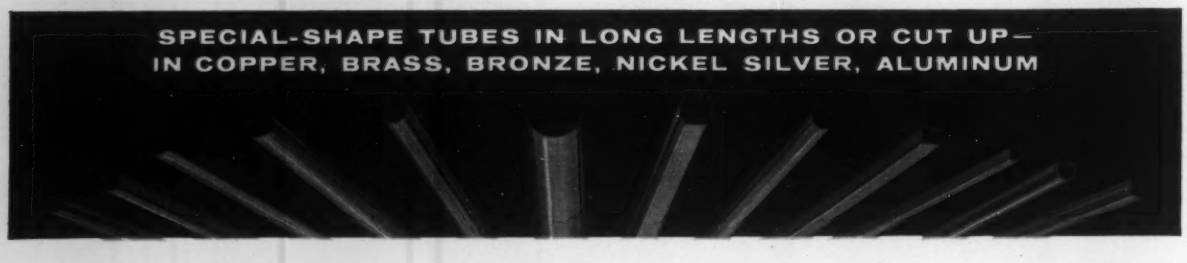

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Engineering News Roundup

CUTTING SQUARE CORNERS and operating close to fence rows are two harvesting problems overcome with Ford's new self-propelled windrower. The new machine cuts and delivers grain or hay to the center, unlike conventional mowers. A four-cycle, 30 hp engine with electric starter provides speeds of 2 to 8 mph. Planetary transmission directs motive power through a chain drive to each of the driving wheels. This permits the implement to turn within its own radius; cut square corners. Reel and cutter bar are hydraulically controlled. The windrower is the first self-propelled farm implement to be developed by Ford Motor Co.'s Tractor and Implement Div.

Forecasts All-Nuclear Task Force in Mid-1960s

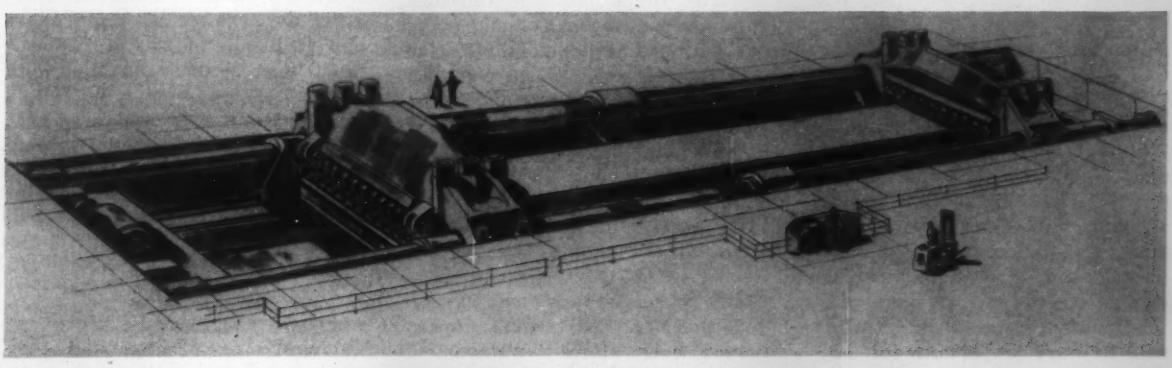
Adm. Rickover Describes Black-Cat Missile Fleet

ATLANTIC CITY, N. J.—U. S. Navy "conversion from oil to nuclear power is taking place so rapidly that it is a revolution. By the the mid-1960s we should have in being the first nuclear task force—complete from submarines to carriers."

Thus spoke Rear Admiral H. G. Rickover at a recent meeting of the American Legion Naval Affairs Committee.

"The history of naval engineering is a record of our efforts to design and build better moving platforms. Our aim has been to develop ships which have these ideal capabilities:

1. The capacity to go at full speed anywhere at any time.
2. The power to carry war to the enemy.



TWICE THE PULL of any stretching machine in existence will be exerted by this 30 million lb plate stretcher being built for Kaiser Aluminum Corp. The big machine was designed to handle aluminum-alloy plate in sizes ranging to 6 in. thick, 160 in. wide, 17 to 60 ft long. A 60-ft workpiece will be stretched as much as 5 ft. Each stretching head weighs 500,000 lb; is supported on either side by eight standard railroad car wheels on a double track. Stretching cylinders operate at 6000 psi. Unique recoil mechanism, capable of absorbing over 15 million ft-lb of energy in each head, will protect the machine in event plate breaks while being stretched at full capacity. Weight of the machine is slightly less than 3 million lb. Kaiser designed the stretcher, Hydraulic G.m.b.H. of Duisburg, Germany, will build it.

ALL-AROUND PERFORMANCE is stressed by Cessna Aircraft Corp. in describing their new four-place helicopter currently under test by the Army. The new craft has maximum gross weight of 3000 lb; will carry a payload of 950 lb. Power is furnished by a 270 hp Continental engine, providing top speed of 124 mph at 8000 ft. Sea level rate of climb is 1350 ft per min; hovering ceiling, under standard conditions, 14,500 ft at 2600 lb gross weight. The YH-41 has a range of 290 mi and endurance of 3.8 hr. It was designed for general utility, reconnaissance, and training.

3. The ability to keep their exact location secret.

"What nuclear power can do for the submarine has already been demonstrated. For the surface ship it will provide virtually unlimited cruising radius. Our aim is to design nuclear propulsion plants which can last for an entire war without being refueled.

"At the outbreak of World War II, Germany had 57 U-boats, or only about one-tenth the number now possessed by the Soviets. Clearly, the task of containing the Soviet submarine menace in the event of war . . . is the Navy's most vital and most difficult defensive mission. We are now developing a nuclear-powered submarine specifically to cope with this threat. We are also designing a nuclear power plant for another type of ship which will be very important for anti-submarine warfare, a frigate. It will be needed to protect our naval forces against submarine attack.

"The nuclear task force will be unlike its closely knit counterpart of World War II. In order to reduce vulnerability to hydrogen bomb attack, the nuclear task force will be dispersed over an area as big as the State of New York. No ship will be within H-bomb radius of another. The enemy would know the exact location of our land bases in advance; but could know only the general location of our sea bases.

"The nuclear propelled submarine capable of launching intermediate range ballistic missiles with nuclear warheads could make our Navy an even more effective deterrent force . . . The Navy is, in fact, now developing such a missile, the Polaris. Armed with this missile, the nuclear-powered submarine will become an underwater satellite. These underwater satellites will launch their attack from far out in the Atlantic, the Pacific, or the Arctic Ocean. They could be placed anywhere within 1500 miles of their targets . . . dispersed over literally millions of square miles of ocean . . . The enemy would be in the position of a man trying to find a black cat on a vast and empty plain on a moonless and starless night.

"An aggressor could not escape destruction as long as this missile fleet remained intact. He would be forced to attack it, thus greatly reducing the number of missiles available to him for hitting our territory or that of our allies. . .

"I should make it plain that this weapon cannot be built by the day after tomorrow. It will be a scientific and engineering challenge, comparable in difficulty and magnitude to the first nuclear submarine. In other words, the *Nautilus* did not mark the end of a technological road. It marked the beginning. It should be compared with the first airplane that flew at Kitty Hawk."

Moon Used as Relay Station For Radio Voice Transmission

New Means of Communication Suggested by Navy Scientists

BOULDER, COLO. — Scientists at Naval Research Lab. have succeeded in using the moon as a radio relay station in what is termed the "most significant discovery made by radar." James H. Trexler, chief scientist on the project, announced the accomplishment at a recent meeting of the International Scientific Radio Unions.

First experiments, in 1951, were made with a comparatively low-frequency radar transmitter operating at a power of 1 megawatt and frequency of 200 mc. Pulses of 10 microseconds duration were beamed at the moon. With this installation, it was discovered that the moon was "comparatively smooth" to radar waves and would conceivably act as a relay point for both radar and radio communications.

Encouraged by this result, the

Front Cover

A whirling pattern that almost seems to move as you look at it characterizes George Farnsworth's front cover. Featured article by R. G. Anderson is on high-speed rotating parts, Page 148.

. . . Fluid Power news

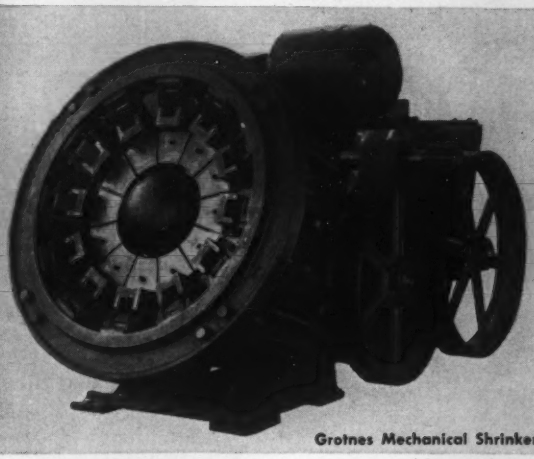
REPORT NO. 11,601
GREATER POWER FOR EXPANDERS — SHRINKERS

From Oilgear Application-Engineering Files

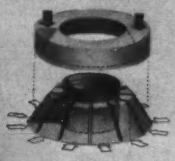
HOW OILGEAR HEAVY-DUTY POWER-PAKS EXTENDED WORKING RANGE OF GROTNES MACHINES

CUSTOMER: *The Grotnes Machine Works, Chicago, Illinois.*

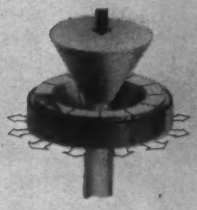
DATA: Grotnes expanders and shrinkers are used for forming and sizing sheet metal parts and heavy rings to tolerances of ±.002″ without heat, machining, or waste. Any continuous cross-section part (square, round, oval, etc.) is expanded over jaws mounted in a slotted table. The jaws are moved radially outward by a drawbar-actuated cone, forming or sizing the part by stressing the metal beyond its yield point to induce a permanent set. In shrinking, the jaws are forced inward against the part by a tapered ring or toggle links. World-wide acceptance of this unique method has led to industrial requests for Grotnes machines with greater working forces, longer strokes, more uniform power than are practical or possible with mechanical drives using gear trains and crankshafts.



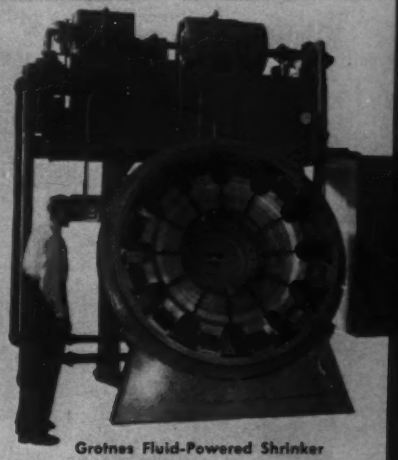
Grotnes Mechanical Shrinker



Grotnes Shrinking Method



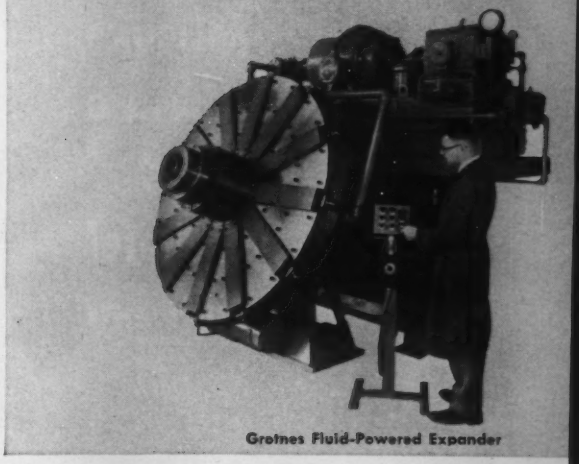
Grotnes Expanding Method



Grotnes Fluid-Powered Shrinker

SOLUTION: Shown above are two Grotnes shrinkers—one mechanically powered, the other Oilgear Fluid Powered for greater tonnage, longer stroke, more uniform power. Note the neat appearance of this new unit with its convenient, simple panel for precise, automatic control. Shown, right, is one of a new line of Grotnes expanders designed specifically for Fluid Power operation. Capacities range up to 1,580 tons on the new expanders; to 800 tons on the new shrinkers—based on 3,000 psi pressure provided by Oilgear application-engineered Heavy-Duty Power-Paks. Performance and control on these new, larger machines has been so outstanding that Grotnes is now equipping expanders as small as 25 tons drawbar pull with Oilgear Power-Paks. This is just one example of Oilgear cooperation and teamwork with designers and builders of machines for industry. An Oilgear Power-Pak is more than just a clean-appearing, unitized assembly of a pump, motor, reservoir, valves and controls . . . it is an efficient, leaktight, easy-to-install, Heavy-Duty Fluid Power system based on over 35 years of pioneering-engineering-knowledge that provides: automatic, electric power conservation; precision-controlled pressures, positions, cycle times; dependable operation; unit responsibility for the entire power system. Because of Oilgear's long reputation for dependable, trouble-free Fluid Power for virtually any application, Oilgear has become a name that all industry trusts . . . and uses.

For practical solutions to your linear or rotary drive and control problems, call the factory-trained Oilgear application-engineer in your vicinity. Or write, stating your specific requirements, directly to:



Grotnes Fluid-Powered Expander

Oilgear application-engineered Power-Paks are also used extensively on hotplate, plywood, pulp-baling, injection molding, extruding, forming, and other presses. Oilgear rotary drive and control systems are equally well accepted in virtually every field of manufacturing and processing. For accurately controlled linear or rotary power . . . for the lowest cost per year . . . check with Oilgear!

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Application-Engineered Fluid Power Systems

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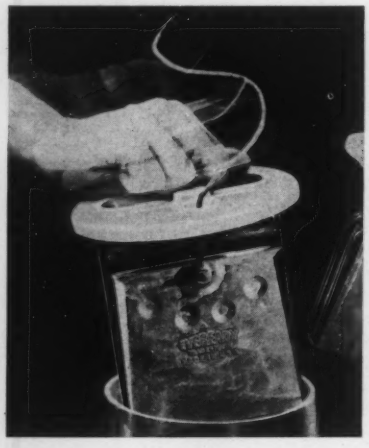
Please direct inquiries to advertiser, mentioning MACHINE DESIGN

SPORTABLE RADIO, an optional feature on the 1958 Pontiac, can be removed from the instrument panel for use as a completely portable unit. In the automobile it automatically connects to the car speaker and car battery. When pulled from the instrument panel, the all-transistor radio reverts to its own battery supply and built-in speaker. "Sportable" measures 8 in. long, 5 in. wide, 2 in. high; comes with leather carrying case.

Navy radio astronomers extended their investigations to super high frequencies, or microwaves. The Laboratory's 600-in. radio telescope was modified to transmit and receive at 3000 mc. With this equipment came the first announcement, on Feb. 24, 1957, that a radar signal had been "bounced" off the moon. The powerful microwave pulse required about 2.5 sec to travel a round trip of nearly 500,000 mi, returning as a weak, but detectable signal.

Continued experiments resulted in round trip voice transmission, according to the Navy announcement, although no dates or other details were described. The Navy concedes, however, that many types of communication may in the future be carried on via the moon.

Mr. Trexler and his associates at NRL also note that their experiments gave a value for the distance between the earth and moon which differ from figures calculated by optical observation. In continuing studies the scientists hope to obtain similar information on the absolute sizes of earth and moon.



MORE CELL, LESS SPACE is claimed for this new air-depolarized signal cell made by National Carbon Co. Rated at 750 amp-hr or 975 whr, it occupies the same space as a 500 amp-hr copper-oxide cell, but provides three times the capacity. Voltage is about twice that of copper-oxide cells. Other features include improved low-temperature properties, higher permissible current drain, and no exhausted elements to process and return.

Topics

Old engines never die—at least one of the first atmospheric gas models won't, for it is being retired to the Smithsonian Institution. A ½-hp, 80-rpm engine built by its inventor, Nikolaus August Otto, has been donated to the museum by the company Mr. Otto founded in Germany.

• • •

Also museumized, a 70-year-old "brain" is now on display at the Chicago Museum of Science and Industry. The machine was developed by Dr. Herman Hollerith, a pioneer in data processing devices, and was used in tabulating the 1890 census.

• • •

A PINK TRAIN? Yessir—just a model, to be sure, but it's as rosy as a bald man's pate in July. Lionel's new catalog offers a pink locomotive and tender, and other cars in delicate shades of blue, lavender, and yellow, calculated to appeal to the distaff side of the young fry. The whole idea seems to shock many he-man model train fanciers; however, it may be a blessing in a pastel disguise to fathers blessed with only girl children.

• • •

Largest Naval combat vessels ever constructed on inland waters will be two guided-missile-carrying destroyers 430 ft long with a beam of about 47 ft. The ships will be built by Defoe Shipbuilding Co., Bay City, Mich. Their boilers will be furnished by Babcock & Wilcox, whose Great Lakes marine manager credits the Seaway with the letting of contracts for these vessels to a Great Lakes yard.

• • •

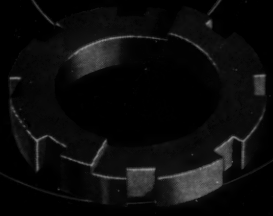
Put the clock out—in the sunshine—will be part of the operating instructions for a solar timepiece reportedly being marketed this fall by Seth Thomas Div. of General Time Corp. One day's exposure to sunlight will keep the clock running for a month.

• • •

Post office (the letter-processing variety) will be automated soon. Electronic machines for sorting mail are being developed; postal planners say mail service can be speeded up 50 per cent in the next ten years.

Circle 408 on page 19→

Not 25 not 50 not 75 but 100%



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skill and experience are
devoted to producing
the world's finest
Powder Metallurgy
Bearings and Parts

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Trends to Future, Realism Mark Varied, Ingenious Toys for '57

Designers offer pastel trains for girls, car steered by sound, voice recorders, as well as old reliables—one a 50-yr grandad

Just as in other fields, designers of toys must strike a careful balance between cost and performance of end items. In addition, a highly competitive market and the very nature of the "consumers" pose continual challenges to imagination and inventiveness.

In 1957, the industry looks for its biggest year yet, and indications are that designers have kept the pace. The variety, ingenuity, and value of this year's toys should please any purse and person.

On these pages and in the next issue, a selection of mechanical and electrical items, most of them new this year, is MACHINE DESIGN's roundup of American-made toys for 1957.

Manufacturers report strong demand for futuristic, atom-age designs and for greater realism in scaled-down modern vehicles. In one notable case the opposite is true. Western Stamping Co. celebrates the 50th year for one of its products — significantly, a coin bank.

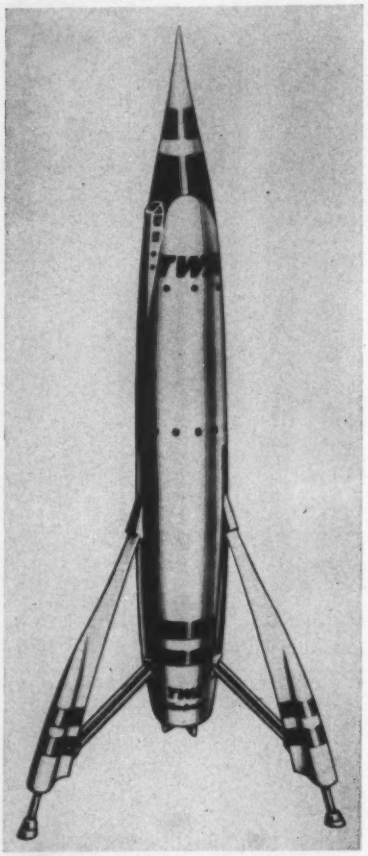
One toy too new to have a full-size counterpart is a land vehicle, named Golden Sonic, steered by sound. Another is an atomic train. One version reflects military use of atom power; a second, peaceful applications.

The trend toward realism is seen particularly in trains. A wide variety of operating accessories are offered. Lines include new auxiliary items such as shifter locomotives and maintenance cars. Here, if not on the big roads, steam is still popular.

Realism is also seen in scaled earth movers. One line includes a remote-controlled street sweeper, which suggests the possibility of rug cleaning by the younger set.

Military toys are still popular. One is an aircraft carrier that launches helicopters. (The "big" Navy has only one—an experimental adaptation.) Other military items are a remote-controlled tank, missile launchers, and a Civil Defense radar station. A military flashback is a pair of mounted knights that joust under remote control.

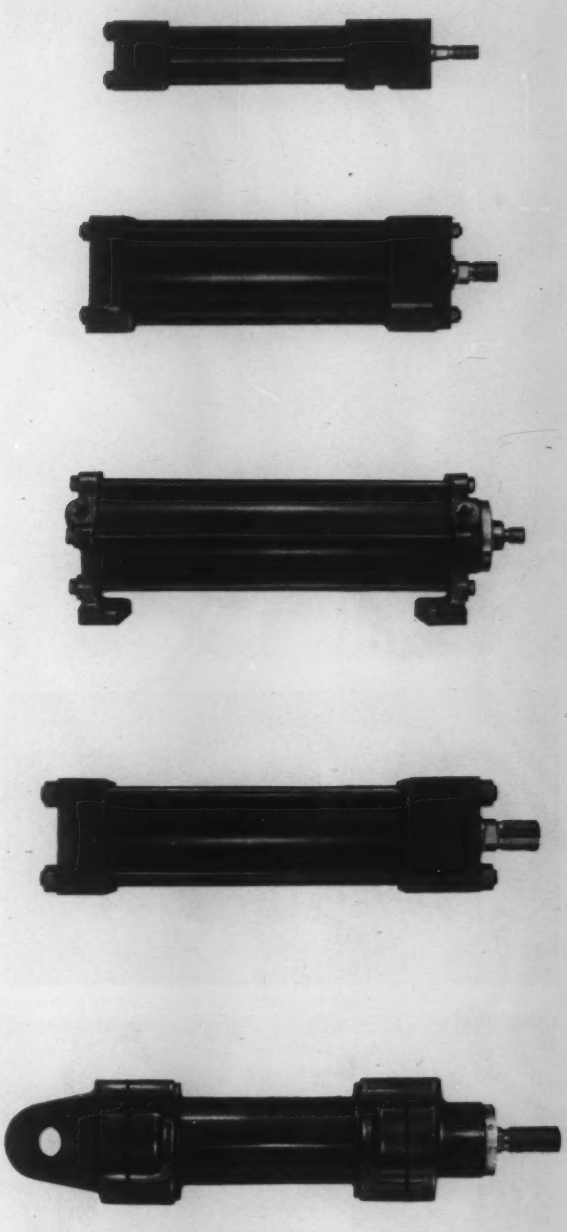
Educational and instructive toys include electrical sets for building radios and telegraphs. One uses solar power; another has transistors. Tool sets include power drills of aluminum or plastic.



SHAPE OF THINGS TO COME is forecast by Moonliner rocket model, a product of Strombeck-Becker Mfg. Co. Made of plastic, the rocket is supplied as a 44-piece assembly kit. Finished Mooliner is 11 3/8 in. high, 4 7/8 in. across base.

AUTOMATIC ENCODER is the nature of the E-Z-Code Jr. made by Aerovox Corp. The device is tied in to a radio or telegraph circuit. Then the electric pencil is drawn down successive slots to form words. Point makes dots and dashes as it passes across spaced bands in a printed circuit.

BUDDING STENOGRAPHERS can learn to type on this machine much like its "real life" counterparts. Tom Thumb typewriter, made by Western Stamping Co., has more than 300 pieces. Nearly all are stampings. It receives 8½ x 11 paper; has 84 characters, the same as big machines; weighs 8½ lb.



Five cylinder series... each the best of its kind!

Here you see one more reason why experienced cylinder users prefer Hannifin cylinders...there is a Hannifin cylinder series for every type of service.

What pictures cannot show you is the extra effort that goes into every Hannifin cylinder, all the way from the drawing board to the shipping dock. This brings you design features other cylinders simply do not have...superior workmanship where it's most needed for long, trouble-free service...and better delivery promises, better kept. All at prices no higher than you may have been paying for less satisfactory cylinders.

There's a Hannifin man near you—or, if the need is urgent, call us long distance. He or we will welcome the opportunity to help you as you select the Hannifin cylinder series that best meets your needs.

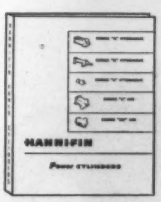
AIR AND HYDRAULIC

HANNIFIN

POWER CYLINDERS

COMPLETE CYLINDER FILE

Write for your copy of this new Hannifin Cylinder File...complete, easy-to-use, easy-to-order-from information on five lines of Hannifin cylinders. Write Hannifin Corporation, 515 S. Wolf Road, Des Plaines, Illinois.



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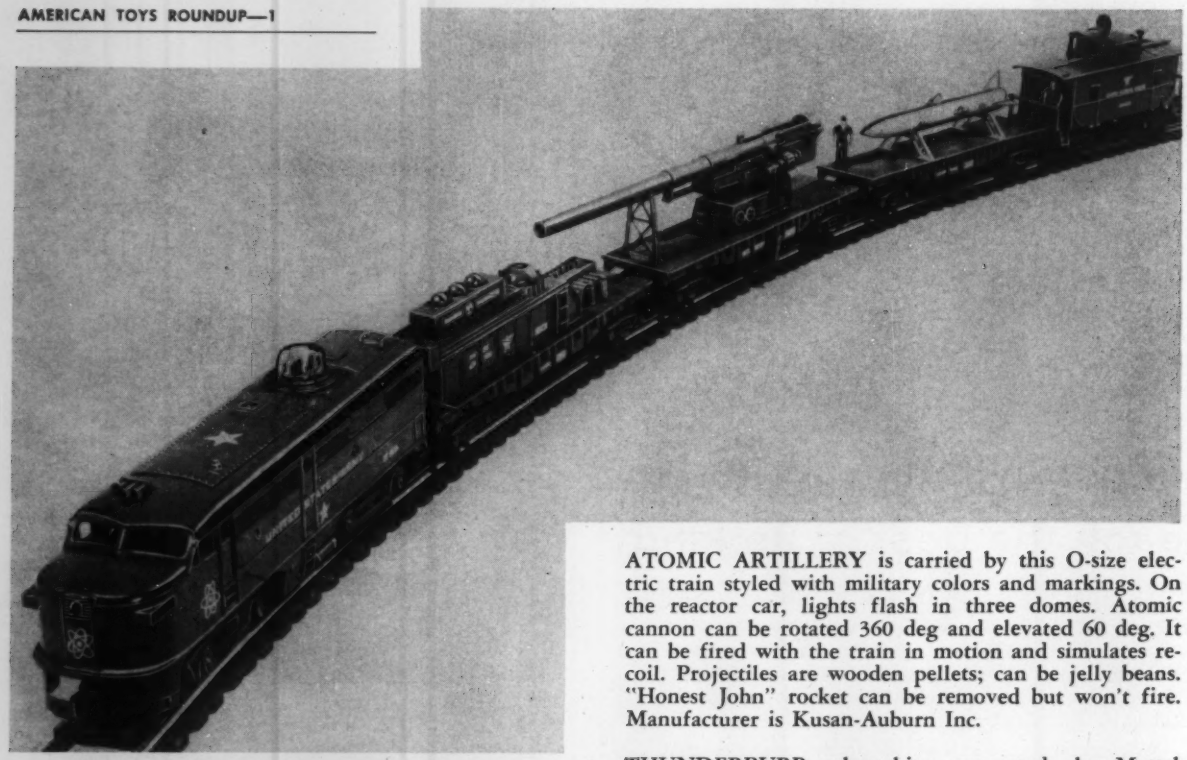
AMERICAN TOYS ROUNDUP—1

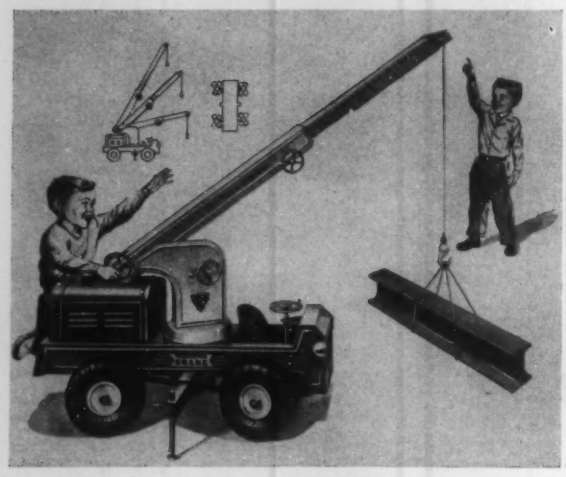


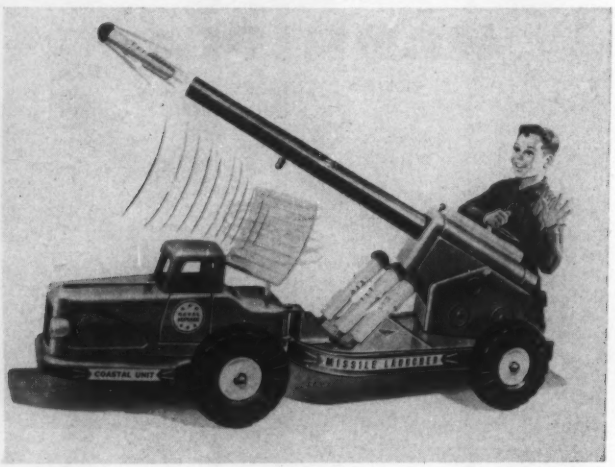
ATOMIC ARTILLERY is carried by this O-size electric train styled with military colors and markings. On the reactor car, lights flash in three domes. Atomic cannon can be rotated 360 deg and elevated 60 deg. It can be fired with the train in motion and simulates recoil. Projectiles are wooden pellets; can be jelly beans. "Honest John" rocket can be removed but won't fire. Manufacturer is Kusan-Auburn Inc.

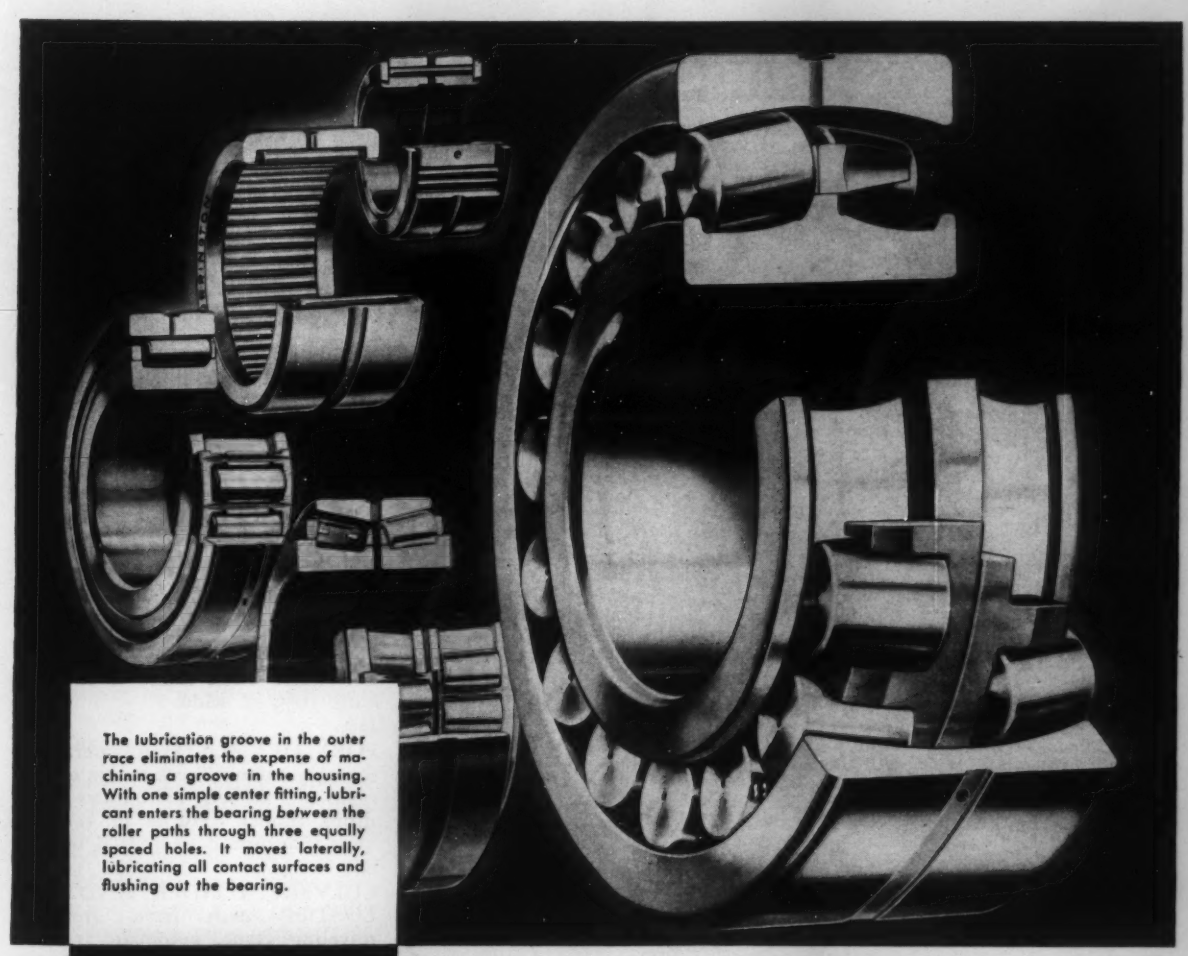
THUNDERBURP submachine gun made by Mattel Inc., fires 20 shots at one loading, but nothing passes the muzzle. Nor does the gun use caps or batteries. Shot-like sounds originate in a special acoustic chamber. Thunderburp is loaded and cocked manually.

FOUR-WHEEL STEERING and multimotion boom are featured on the Telescoping Crane by Ny-Lint Tool & Mfg. Co. Handwheels control boom motions.

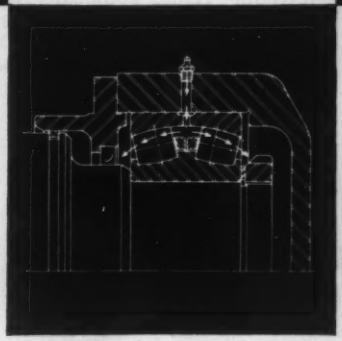
SOFT-NOSE MISSILES made of plastic, harmless, are fired from this mobile launcher, another boy-size vehicle by Ny-Lint Tool & Mfg. Co. All operations are mechanical. Pivoted connection enables steering.







The lubrication groove in the outer race eliminates the expense of machining a groove in the housing. With one simple center fitting, lubricant enters the bearing *between* the roller paths through three equally spaced holes. It moves laterally, lubricating all contact surfaces and flushing out the bearing.



A time-proved lubricating method now available on Torrington Spherical Roller Bearings

The circumferential groove in the outer race has met the test of experience in many Torrington Bearings, including Heavy Duty Needle Bearings, Aircraft Type Needle Bearings, Tapered and Radial Roller Bearings. Now the circumferential lubrication groove is available in Torrington Spherical Roller Bearings.

This design feature makes it possible to introduce lubricant *between* the roller paths without the expense of machining a groove in the housing. This groove is proportioned to provide generous lubricant flow capacity. Lubricant moves through the roller paths, flushing used lubricant and contaminants away from bearing contact surfaces.

Torrington Spherical Roller Bearings in many sizes may be ordered with this groove as desired at no additional cost. For further information, see your Torrington representative or write: **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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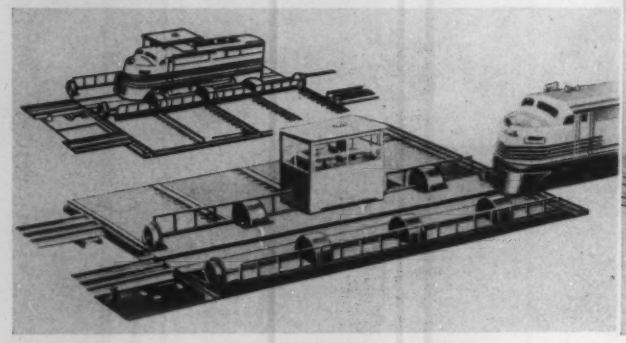
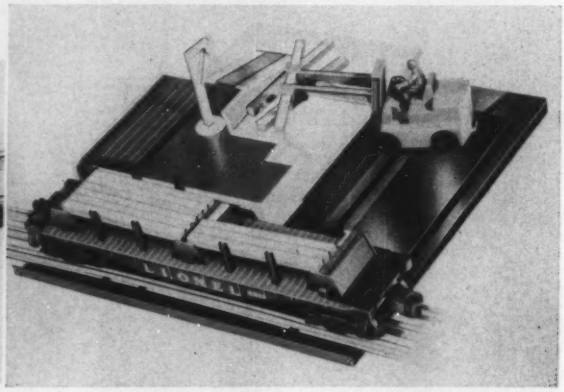
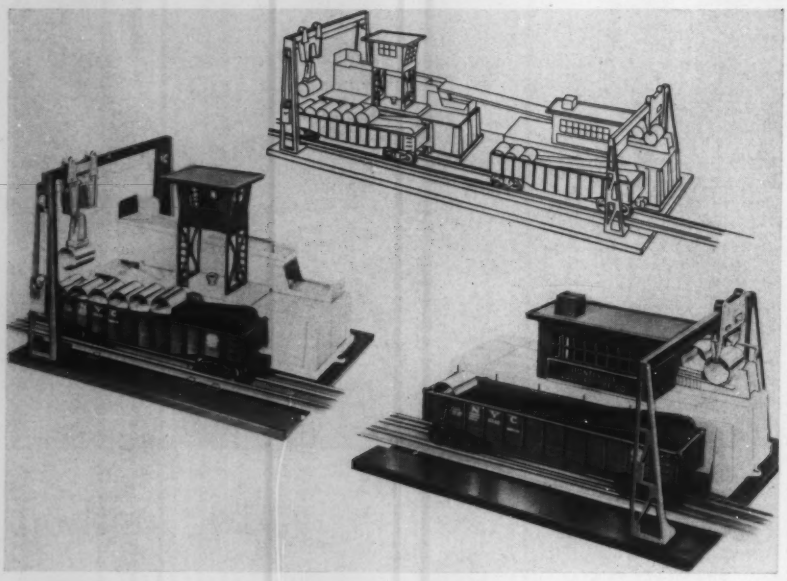
AMERICAN TOYS ROUNDUP—1







New in the Lionel line for 1957 are realistic Super-O track, Norfolk and Western steam loco, snow plow, and these operating accessories:

Above, left

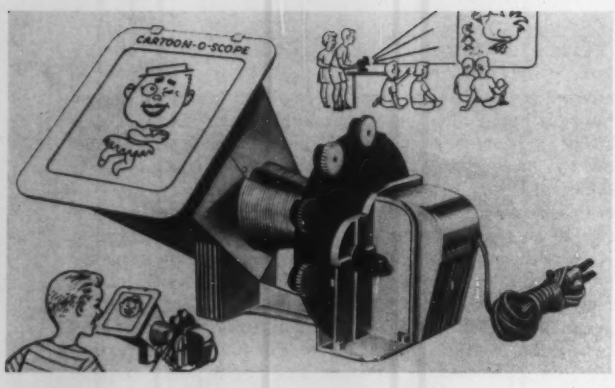
ENGINE TRANSFER TABLE moves loco from one to another parallel track. Table measures 17½ in. long, 10⅜ in. wide.

Above

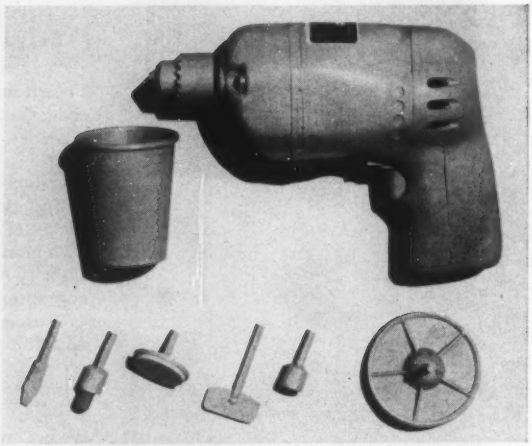
FORK LIFT PLATFORM performs four operations. Truck moves to car, removes timber, withdraws and drops timber, returns to car for more. Platform is 10 by 10⅝ in.

Left

CULVERT LOADER AND UNLOADER each have overhead traveling crane, automatic, remote controlled. Operations are made continuous by joining the two with culvert ramp. Space occupied is 12¼ by 9½ in. (Unloader) and 12¼ by 9½ (Loader).



THOUSANDS OF FUNNIES, 54,000 exactly, can be made with Cartoon-O-Scope, a product of Product Miniature Co. Subjects are humans or animals. Four dials add varied heads, features, bodies, and situations, respectively. Pictures can be traced from scope's own screen or projected, with screen removed. Scope is for boys and girls; adults not excluded. All parts are made of colored styrene plastic.



MANY TOOLS FROM ONE can be assembled with this battery-powered Play Drill, made by General Molds and Plastics Corp., ¾ the size of Black & Decker original. Drill stalls safe under load.

Engineer Prefers Opportunities In Management, Survey Shows

Discloses His Nonsalary Satisfactions, Irritations

WASHINGTON—Engineers feel they are treated better than accounting, personnel, public relations, and advertising people of the company; not so well as production and sales people, states a newly published survey report.

They have a yearning for greater professional recognition—both inside the company and outside of it, but are uncertain as to just what form this recognition should take or how it can be achieved. Higher salaried technical people exhibit greater professional activity than those at the lowest level. The more successful engineer stands out as a more aggressive, more active person, both in his work and outside of it.

Definite Management Interest: When asked "Assuming an engineer could advance just as far in strictly engineering work as he could by moving into management, which way would you personally prefer to direct your career?" 49 per cent voiced a preference for management. Of the remainder, 38 per cent chose to stay with "strictly engineering" and the others offered either qualified answers or no opinion.

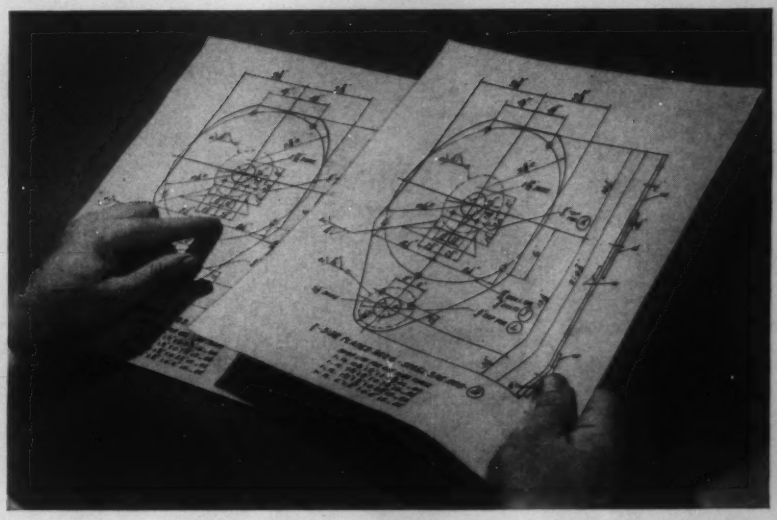
However, when asked "Is there ample opportunity for engineers to advance within engineering . . . ?" 68 per cent thought there was. The implication, the report suggests, is for industry to find some means of selection that will suit both company and engineer. Motivation to outstanding technical performance may be weakened if ultimate reward is a managerial position.

The Survey: These are some of the findings in the newly published survey report, "Career Satisfactions of Professional Engineers in Industry," sponsored by the Professional Engineers Conference Board for Industry in cooperation with the National Society of Professional Engineers.

Report of the comprehensive sur-

(*Please turn to Page* 22)

DRAFTING TRENDS



Even a printmaking expert cannot look at these two prints and tell which original drawing was made on Phantom Ruled Blutex. Still, there were hours of difference in drafting time required to make the two identical drawings from which these prints came. Write today for a free sample of Phantom Ruled Blutex and see the proof for yourself.

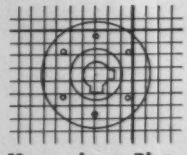
Phantom ruled vellum leaves more time for creative drafting

Working with scaling aids often takes valuable time from the basic job of creative drafting. Add the wasted hours spent drawing guide lines, lettering and handling similar routine drafting problems, and you have the reasons why POST developed Phantom Ruled Blutex.

This new vellum is basically POST's Blutex, unchanged except for the addition of phantom grid lines. The result is a combination of all the time-saving advantages of grid paper with all the drawing and reproduction advantages of famous Blutex vellum.

By using the grid lines, a draftsman works quickly to scale without constantly reaching for scaling instruments. Proportioning and resizing are easier and faster. Freehand drawing truly becomes a rapid, highly creative method of recording ideas. Even lettering and dimensioning are transformed into simpler, less time-killing jobs.

In printmaking, the grid lines disappear completely, leaving a sharp, contrasty print.



More about Blutex

The carefully controlled, uniform tooth on Blutex's surface easily "takes" dense, opaque pencil lines that resist smudging and smearing. Those sharp lines, plus Blutex's excellent transparency, assure fast printback and sharp reproductions.

Due to its carefully selected 100% rag content base, Blutex stands up well under prolonged handling. Even when alterations are done years after an original drawing is completed, Blutex still retains its fine ghost-free erasing qualities and easy erasability.

Free sample offer

For a test sample, write to the Reader Service Division of Frederick Post Company, 3652 N. Avondale Ave., Chicago 18.

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GEAR-MAKERS TO LEADING MANUFACTURERS

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for More Information . . .

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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OCT. 17, 1957

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403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
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413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
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419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
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422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
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426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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MACHINE DESIGN
OCT. 17, 1957

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401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
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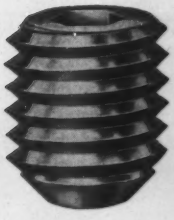
how to keep costs down



...profit margins up!

ALLEN Engineers will show you how you can save time and money by using standard* ALLEN Hex-Socket Cap and Set Screws instead of specials.

Let's get this straight right away... if your product design MUST have special cap or set screws, then ALLEN's the place to come for them.

But our engineers have found, from a good many years of experience, that designs frequently call for *special* hex-socket cap and set screws that are only slightly "off-standard." These specials take longer to get, cost more.

Allen engineers can probably save *you* both time and money by working with you on ways to use *standard* Allen Hex-Socket Cap and Set Screws, where specials may seem to be necessary. Just send blue prints, or good descriptions, of your product designs to our Engineering Department, or talk with your Allen Field Representative.

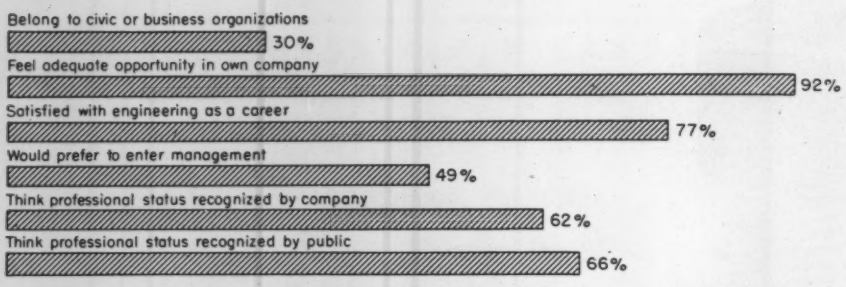
***ALLEN manufactures 1457 *standard* items**

Stocked and sold by leading industrial distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

ALLEN HEX-SOCKET SCREWS HEAD

Circle 412 on page 19



Sampling of answers shows engineers are not "joiners," look toward future with own company, satisfied with calling. They do keep eye open to opportunities in management, feel reasonable professional dignity.

(*Continued from Page* 15)

vey, conducted by the Opinion Research Corp., is based on data gathered from interviews with 265 engineers. Each holds one or more degrees in engineering and is employed by one of eleven American manufacturers included among the 200 largest. Lengthy "depth" interviews were designed to bring out opinions of engineers at three stages of professional experience—3 to 6 years, 10 to 15 years, and 20 to 25 years.

Engineers in this survey showed above average income; median income in the 3-to-6 year experience category is $7500; in the 10-to-15 year group, $10,000; and in the 20-to-25 year group, $12,000. Of the group, three out of four are married and have at least two children. Sixty per cent worked for only their present employer.

Engineers' Likes, Dislikes: At all stages of their careers, engineers liked best their fellow workers, the nature of the work itself, their advancement opportunity. They liked least their working quarters, lack of clerical assistance, lack of definition of authority and responsibility. Engineers with less experience tended to appreciate training opportunity; felt they are not recognized and treated as part of management. All enthusiastically endorse a wide range of nonfinancial marks of importance:

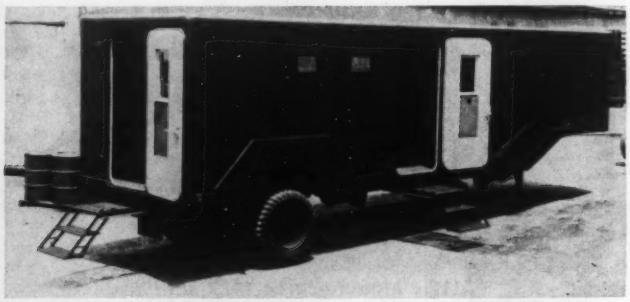
- Keeping them informed.
- Asking for their ideas on relevant matters.
- Identifying their names with their work.
- Showing how their work fits into the total picture.

They also reach broad agreement on the basics of a satisfactory career:

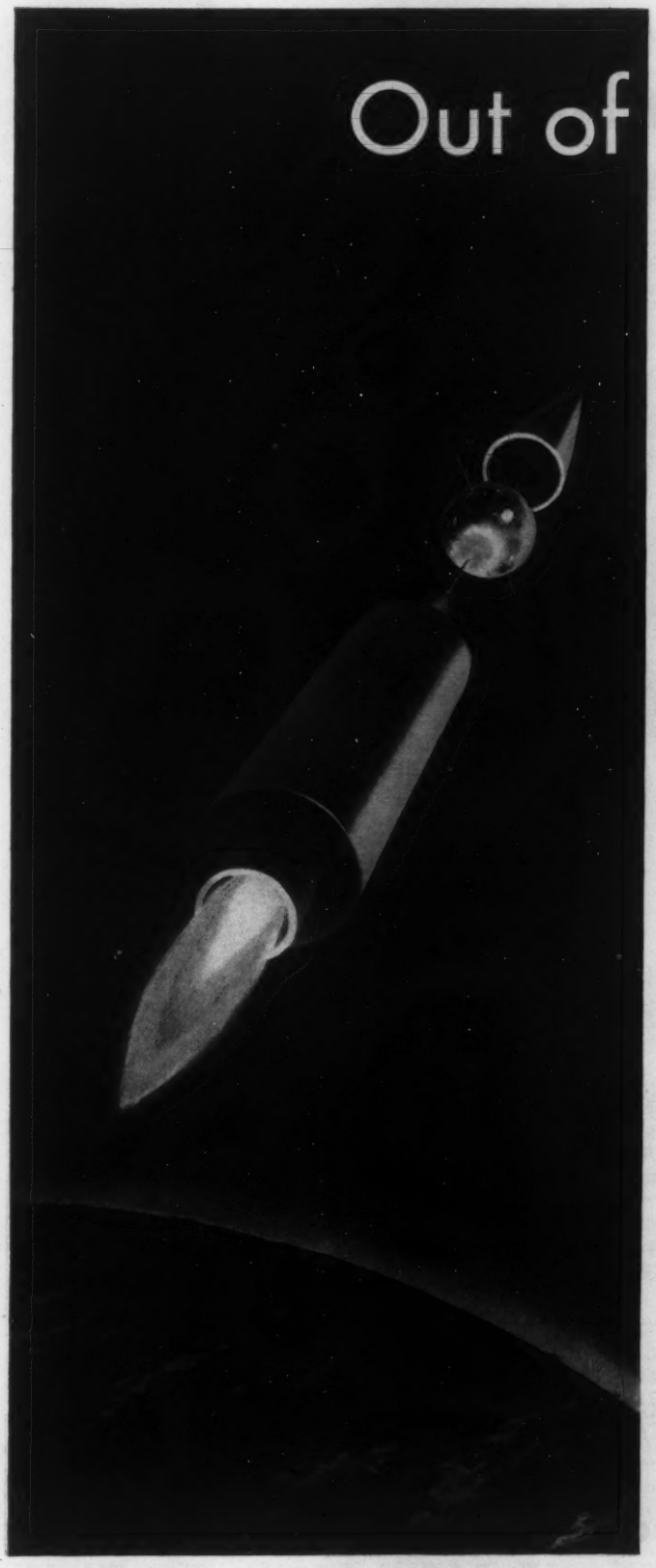
- Challenging work.
- Advancement opportunity.
- Good salary.

So far as the practicing engineer is concerned, basic appeal of engineering lies in the work itself. Essentially the same observations are made by those of more recent entry into the field as from those who have long service in it. The fact that engineering offers financial rewards is mentioned but the tone is that the pay is adequate, not that the money alone is sufficient. One engineer's comment is

LEAD CAB on this Army bulldozer will permit early clean-up of radioactive areas in event of nuclear war. Cab weighs 5000 lb; contains tractor controls, radiation meters, and is pressurized with fresh, filtered air. Lead glass windows provide operator visibility. Cab can be mounted in 30 min by three men and a crane; was developed by Army Engineers' Research & Development Laboratory.



PLASTIC VAN makes many Army electronics installations air transportable. Developed by Hupp Corp., this 30 x 7 x 7 ft trailer weighs 9000 lb; 3000 lb less than conventional units. Constructed of color-impregnated 4 x 8 ft plastic panels, the Hupp Mobile Van never needs painting; resists water, salt spray, fungi, and weather. The 2-in. thick panels provide insulation equal to 4 in. of conventional insulation. Modular design allows doors and windows to be located anywhere in the van. Special 3-in. foam rubber cushion under the fifth wheel absorbs vertical shocks from the towing vehicle; permits safe movement of sensitive instruments.

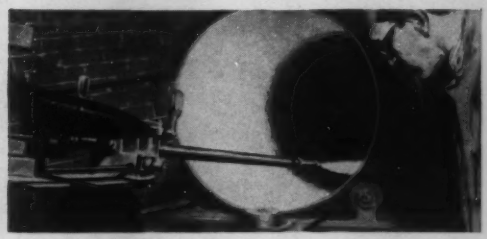


Out of this world!

Norton ROKIDE coating may aid in launching the satellite at the end of its final rocket ride — 300 miles high*

In the Defense Department's *Project Vanguard*, a three-stage rocket is planned to carry a shining satellite into an orbit hundreds of miles above the earth. The third and last stage of the rocket will reach approximately 18,000 miles per hour when it releases the satellite 300 miles above the earth.

One of the third-stage rocket engines being tested for Project Vanguard — and successfully flown last May 1st — was manufactured by The Grand Central Rocket Company of Redlands, California. To help contain the terrific



energy release required to reach this supersonic speed, the inside of its nozzle is protected with ROKIDE "A" aluminum oxide coating applied by the Metallizing Company of Los Angeles.

Besides ROKIDE "A" other Norton ROKIDE spray coatings include "ZS" zirconium silicate and "Z" zirconium oxide. All are hard, adherent crystalline refractory materials. All can be applied to base materials, particularly metals, of a wide variety of shapes and sizes.

Parts on which ROKIDE coatings are especially useful are those requiring thermal or electrical insulation . . . refractoriness . . . resistance to wear or corrosion . . . high melting points . . . excellent mechanical strength . . . dimensional stability . . . relative chemical inertness.

Proved in such critical applications as reaction motors and some A.E.C. projects, ROKIDE coatings are also of great value to general industry. Other Norton high-purity, chemically-stable refractory materials are helping industry to break through the "thermal barrier."

Facilities for applying ROKIDE coatings are available at Norton Company, Worcester, Mass., and Santa Clara, Cal., and at strategically located licensee plants. For complete facts, write to NORTON COMPANY, New Products Department, 769 New Bond Street, Worcester 6, Massachusetts.

NORTON

NEW PRODUCTS

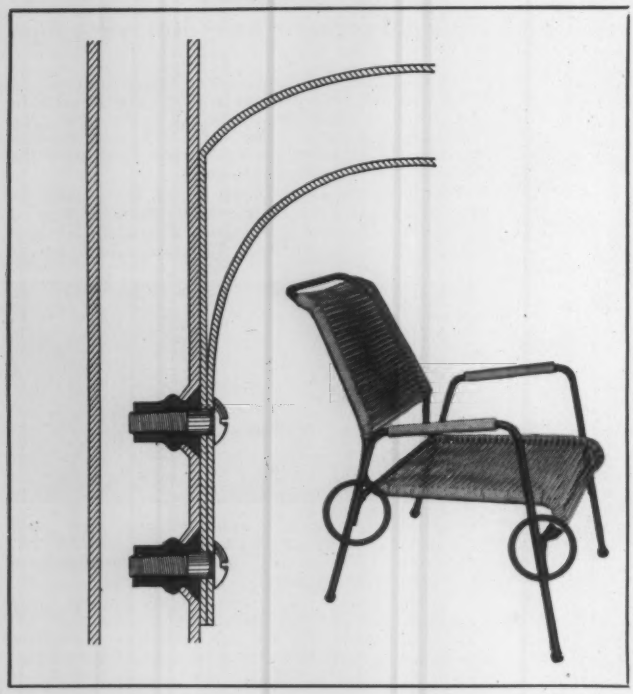
Making better products . . . to make your products better

NORTON PRODUCTS
Abrasives • Grinding Wheels
Grinding Machines • Refractories
BEHR-MANNING DIVISION
Coated Abrasives • Sharpening Stones
Pressure-Sensitive Tapes

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

Circle 413 on page 19

Only B.F.Goodrich Rivnuts® give you firm, blind nutplates for tubular applications!



Finding a fastener that would preserve the clean, functional lines of their modern tubular furniture was a problem for the O. Ames Company. Stove bolts and screws projecting from the legs were not only unsightly, but were a major sales deterrent to a woman in 51 gauge nylons.

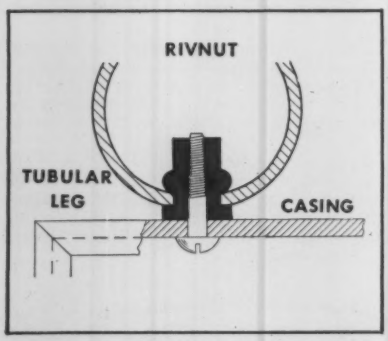
B. F. Goodrich Rivnuts provided the answer to this problem. Upset inside the tubular legs, Rivnuts with countersunk heads fit flush, take round headed attachment screws. In addition, Rivnuts hold firmly and permanently because the bulge in the Rivnut shank conforms to the curvature of the tube. Rivnuts are installed by one man in seconds, and provide an accurate nutplate for quick assembly of the finished product.

If you want to do a smoother fastening job, or are looking for ways to fasten faster and at less cost, use B. F. Goodrich Rivnuts.

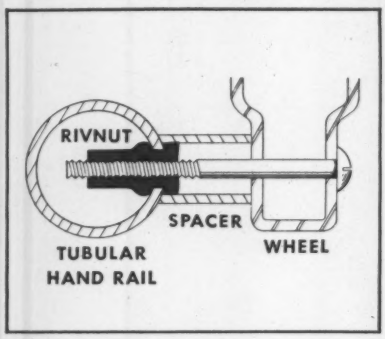
SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to B. F. Goodrich Rivnuts, Dept. MD-107B, Akron, Ohio.

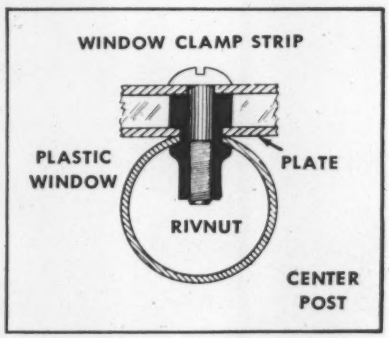
Rivnuts solve a variety of tubular fastening problems like these



Switching to Rivnuts speeded assembly of barbecues. One man installs a Rivnut in the tubular leg in seconds. There are no boltheads to detract from the unit's clean lines. Time is saved in faster knockdown for shipping.



Designers of a wheel chair needed a blind fastener with at least 6 clean threads to serve as a nutplate. Rivnut upset inside the tubular handrail of the wheel chair provides firm, accurate, nutplate for bolt attachment to the wheels.



Upset Rivnut secures airplane window plate to center post. Firm bulge in shank seals weather out. Rivnut head serves as spacer for plastic window, while 6 clean threads hold clamp strip and window securely in place.

B.F.Goodrich

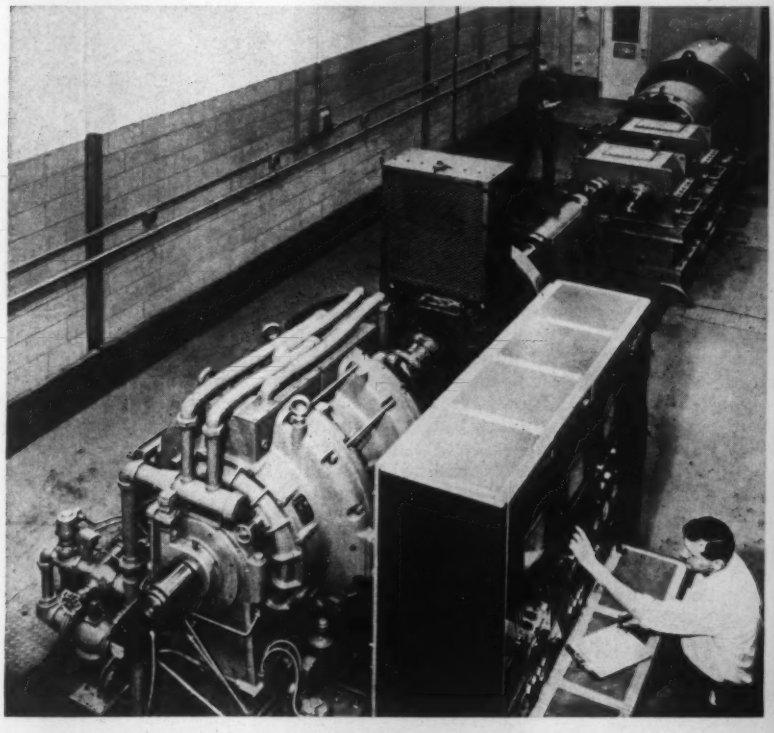
B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio

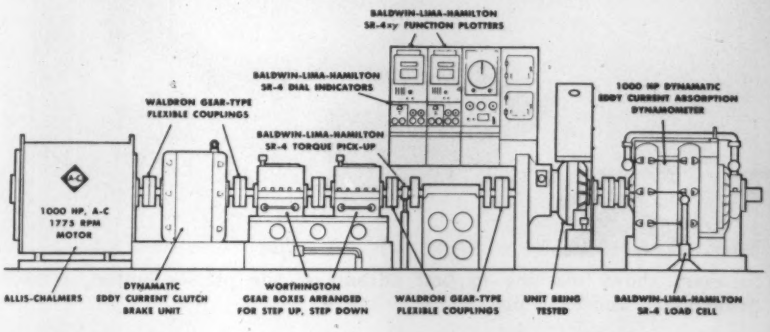
Circle 414 on page 19

"There is the satisfaction of creating something, developing new ideas and techniques. An engineering job leads to management and other responsible postions."

Future Is Comfortable: Overwhelming view of engineers at all stages of their careers is that their company offers career opportunities of the kind they want. They observe they are working for large, strong, progressive, growing companies. One engineer makes the point, "This company promotes from within the ranks of employees and anyone willing to work and having ability to advance will be." In general, the professional engineers are satisfied with the field.



AUTOMATED DYNAMOMETER measures performance of heavy-duty single and multiple-stage torque converters at Twin Disc Clutch Co. The big machine delivers 1000 hp to a test torque converter at speeds from 900 to 3000 rpm; develops 8000 lb-ft torque from 0-900 rpm. It will absorb 17,500 lb-ft torque at 75 rpm and 20,000 lb-ft torque at full stall, with top input speed of 3000 rpm. Instrumentation for the new unit, developed by Baldwin-Lima-Hamilton Corp., permits direct plotting of performance curves in less time than required to fix a single point using conventional methods.


BALDWIN-LIMA-HAMILTON SR-4xy FUNCTION PLOTTERS
BALDWIN-LIMA-HAMILTON SR-4 DIAL INDICATORS
WALDRON GEAR-TYPE FLEXIBLE COUPLINGS
BALDWIN-LIMA-HAMILTON SR-4 TORQUE PICK-UP
1000 HP DYNAMATIC EDDY CURRENT ABSORPTION DYNAMOMETER
1000 HP, A-C 1775 RPM MOTOR
ALLIS-CHALMERS
DYNAMATIC EDDY CURRENT CLUTCH BRAKE UNIT
WORTHINGTON GEAR BOXES ARRANGED FOR STEP UP, STEP DOWN
WALDRON GEAR-TYPE FLEXIBLE COUPLINGS
UNIT BEING TESTED
BALDWIN-LIMA-HAMILTON SR-4 LOAD CELL

Do you think of pressure transducers?

The Martin Company does...

and uses Statham Model PA183 pressure transducers in the SeaMaster program.

The Navy's P6M Martin SeaMaster is a 600-mile-per-hour pioneer aircraft of tomorrow's mobile seaplane striking forces.

The Model PA183 pressure transducer is available in ranges from 0-5 to 0-1,000 psi absolute with characteristics ideally suited to flight test. The transducing element is the rugged Statham unbonded strain gage. A feature of the design is that the case permits stacking one instrument upon another.

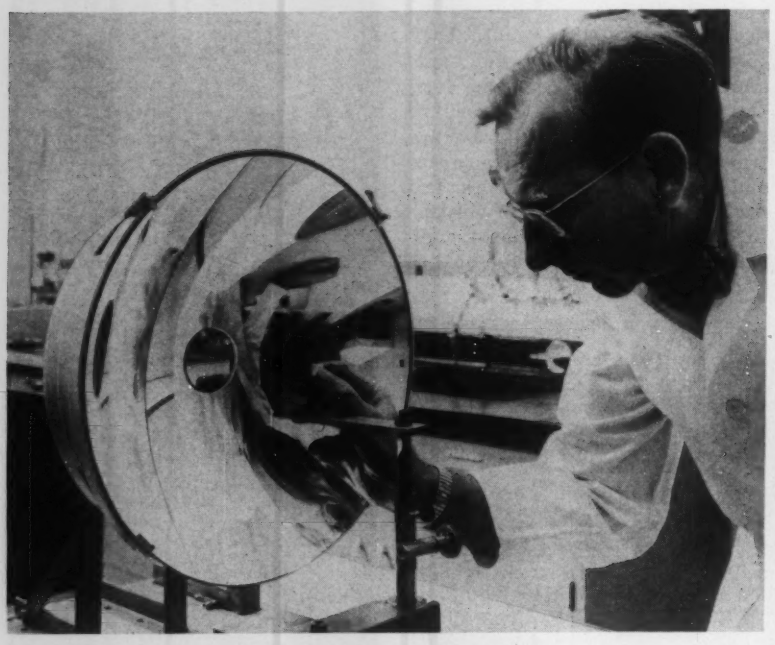
WHEN THE NEED IS TO KNOW... FOR SURE SPECIFY STATHAM

Please request Bulletin No. PA183TC

Statham LABORATORIES

LOS ANGELES 64, CALIFORNIA

Circle 415 on page 19



INTENSE HEAT produced by the arc image furnace is this close-up of the melting of a piece of high-temperature firebrick. Seconds after being exposed to the high-energy beam of the arc image furnace, the brick begins to melt and molten material literally flows. The furnace, developed in connection with high-temperature studies of National Carbon Co., can produce temperatures in excess of 7000 F. Unique feature is use of two elliptical mirrors rather than common parabolic type. One directs energy of the arc to the other, which concentrates radiation on the specimen being heated. An extremely "clean" source of high temperatures, the furnace is said to be ideally suited to metallurgical research where purity is particularly important.

Microfilm Reader-and-Printer Aids Access to Technical Data

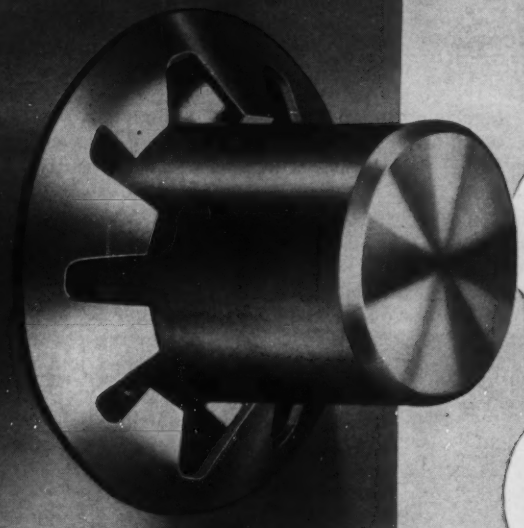
Automatic Processing Gives 8 x 10 Print in 10 Seconds

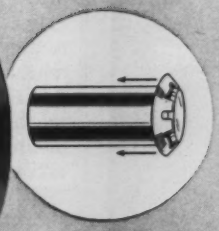
NEW YORK — A machine that prints enlargements automatically will facilitate making copies of microfilmed drawings, research reports, specifications, and other technical data. Several-fold increase in the number of firms using microfilm for their "active" files is predicted by Minnesota Mining & Mfg. Co. as a result of the new microfilm combined reader and printer. Previously, the absence of a fast, economical method of copying, company officials say, had limited microfilm use generally to storage of seldom-seen documents.

Big advantage of the new machine is speed and simplicity of operation. Other viewer-printers currently on the market require

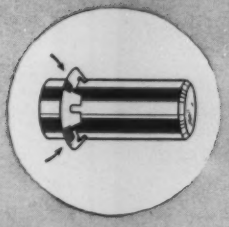
Secretary shows machine to best advantage: she presses button, extracts printed copy and reads image.

Circle 416 on page 19→





Pilot teeth guide fastener on for easy hand starting.



Hardened spring steel teeth bite in, resist dislodging force.

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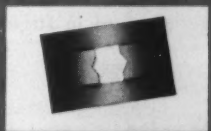
Made of non-aging, chemical resistant vinyl . . . act as positive holding shoulder.



FASTEX® Push-On Fasteners
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FASTEX® "C" Ring Retainers
The fast, simple method for retention or spacing on rods or shafts . . .

FASTEX® External-Tooth Springrip Fasteners
For use in tubes or bored holes . . . provide spring lock for positive retention.

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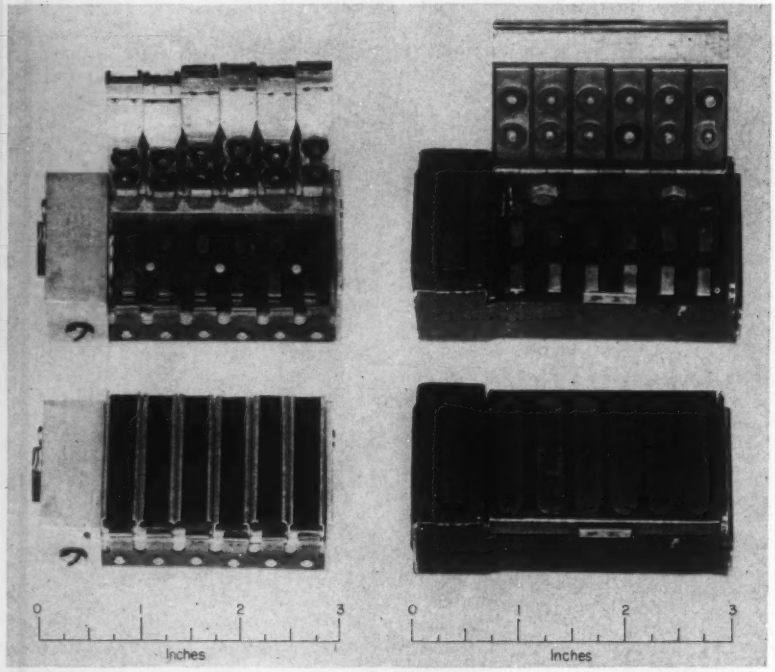
Circle 417 on page 19

print developing outside the machine, with one to three minutes required for each print. The new machine is fully automatic. Film developing and printing, by electrochemical process, are accomplished internally. Ten seconds after button is pushed, an 8 x 10-inch print slides out of slot above the viewing screen.

Operation consists of turning knob to locate microfilm frame, dialing a printing time, which once set is rarely changed, and pushing a button to make a print. "Break-in time for a stenographer is about two minutes," the firm said.

The paper can be stored and loaded in normal office light. Only other operations required are inserting the roll of print paper as needed and pouring in about half a cup of chemical a week.



Compact warning light fixture permits mounting in eyelevel location despite decreasing available space in modern military aircraft. One prototype has a push-to-test bar at one end which can be used to test all indicator lamps simultaneously. Models are designed for flush mounting and arranged so that individual lamps can be changed in flight.

Navy Aero Mini-Lights Put Warnings Where They're Wanted

WASHINGTON—More lights in less space is a design objective achieved in a battery of warning signals intended for Navy aircraft instrument panels. National Bureau of Standards developed the light set for the Navy Bureau of Aeronautics as a standard aircraft installation.

Six subminiature lamps are arranged in a cluster only 3 in. wide. Small size permits positioning the cluster immediately in front of the pilot where the trend to more complicated aircraft puts space at an ever-higher premium.

Two prototypes demonstrate the advantages of grouped light fixtures over separate indicators in size, weight, and mounting simplification. Over-all weight, 4.5 oz, as well as panel space occupied, is approximately equal to that required by three separate indicator lamps. Further size and weight reduction may be expected through

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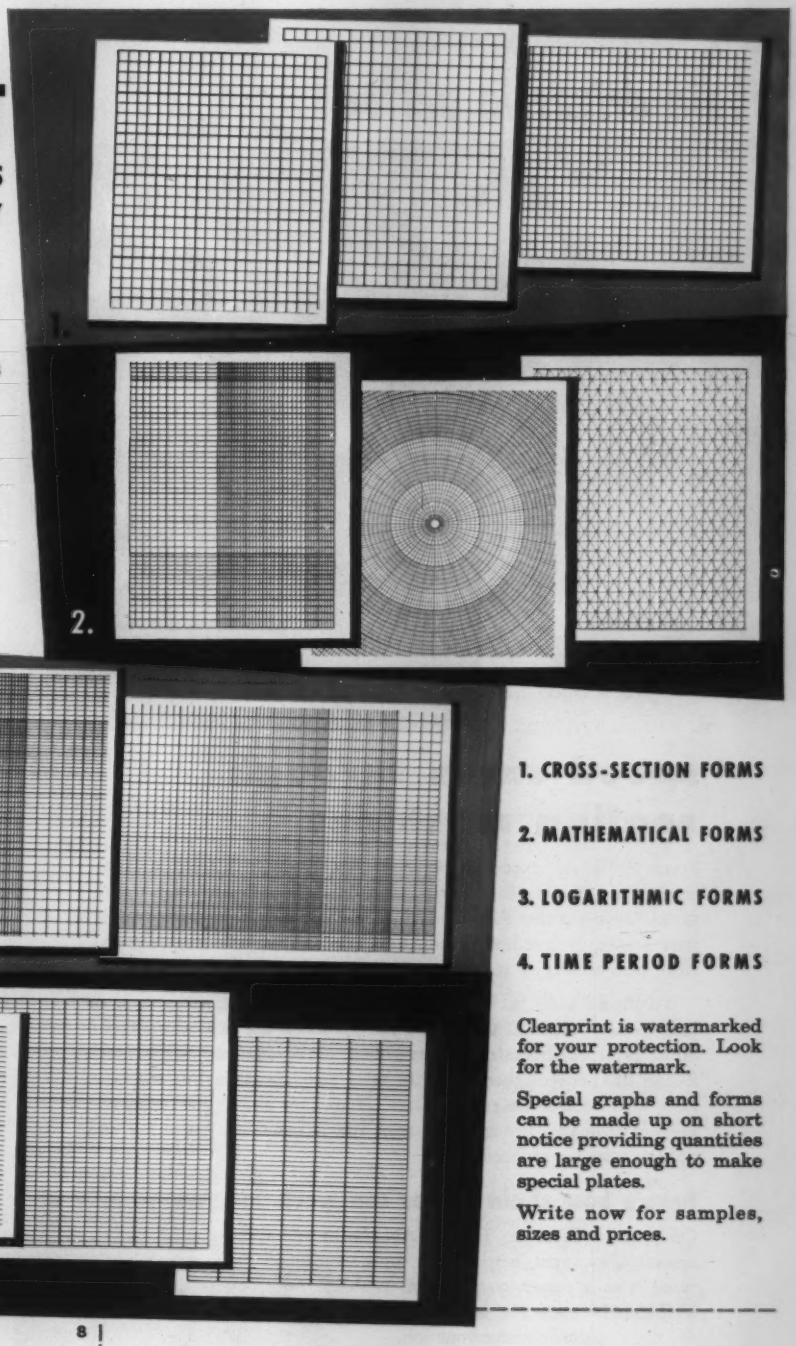

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Circle 418 on page 19

speed cases through sealing machines

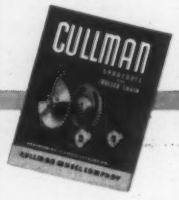
From 300 to 1300 cartons per hour flow through this Elliott Automatic Case Sealer. Each carton is folded, compressed and tightly glued. Different case sizes used in the food and fruit packaging industries are easily handled. Production rates are adjusted as required. And, case sealing is reduced to a simple, clean, one-man operation.

To insure such performance — continuous production at high or low speeds — CULLMAN chains and sprockets are used throughout. Short centered drives rotate the rollers. Long centered drives, with a cross-bar between them, feed the cases through the sealing machine. Both chain drives are synchronized. Here, they absorb overloads and prevent slippage; hence, equipment life is extended, operating and upkeep costs are reduced.

here's how chain drives can work for you...

On your products too, CULLMAN chains and sprockets can achieve similar advantages, help deliver top performance. Next time you are faced with a power transmission problem, write direct or call in a CULLMAN man. He will be glad to assist you — and recommend the right chain drive for your job.

For the full story on the Cullman power transmission line — roller chains, sprockets and flexible couplings, write today for catalog No. 51, or see your local Cullman Distributor.



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application of production methods of manufacture.

Each miniature light fixture contains six indicating lamps to warn pilot, by appropriately illuminated legends, when operation is amiss. The units, employing two type 327 subminiature lamps for each indication, operate from 28 v ac or dc.

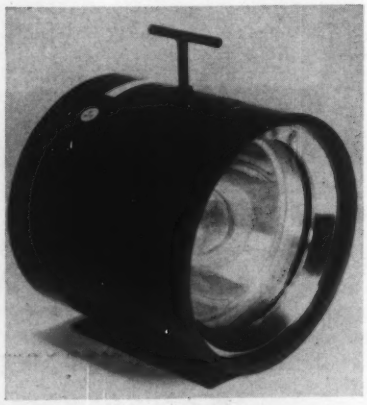
In production, printed circuit conductors may be substituted for phosphor-bronze used in the prototypes. The special push-to-test switch used on one prototype is relatively simple to fabricate, requires no complicated adjustments, and permits numerous contacts to be made within a small space.

Atom-Powered Lamp Bright Ten Years, Trouble-Free

Commercial, Isotope-Excited Signal Lamps Need No Power

MORRISTOWN, N. J.—Atomic-powered, warning lamps that provide light for ten years with no external power or maintenance required are in commercial use. Latest lamp manufactured by U.S. Radium Corp., Model 535, retains ready visibility at 500 yd, but is lighter and less bulky.

Lamps are in current use as obstruction markers on highways; warning signals on railroads. New lamp is 6 in. long, has 5-in. luminous diameter, weighs 10 lb. Range of future applications includes use



New model of krypton-85 atomic powered lamp emits no appreciable radiation, can be fitted with selective filters for standard signal use.

Technician installs signal lamp for visibility tests.

in mining, transportation, marine, and heavy industries, where little or no power for illumination is available.

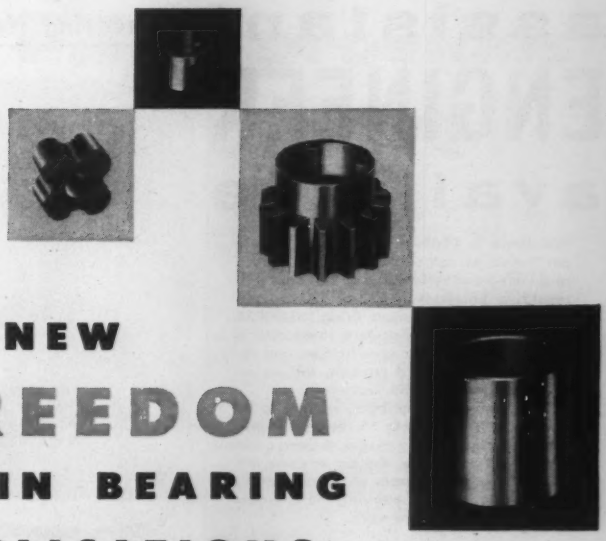
Housed in hermetically sealed, transparent capsules, lamps employ treated phosphor crystals excited to luminescence by krypton-85 gas. Krypton-85, being chemically inert and relatively free from penetrating radiation, is safe in the event of accidental rupture of the light source housing; contents are readily diluted and dissipated on contact with air.

Type of phosphor used to coat lens determines color of emission. Without use of filter, light may be blue, green, yellow, or orange-red.

Plastic Cartridge Cases Lighten Logistics Load

SILVER SPRING, MD.—Reduced weight plus the use of nonstrategic materials feature new plastic cartridge cases developed by Naval Ordnance Lab. The old standard brass case weighs 5.9 lb compared to 2.5 lb for the new plastic model. Considering that the military fires several million rounds of 105-mm ammunition annually, during peacetime, weight saving becomes a logistic factor of major importance.

In test firings using a 105-mm howitzer, the new cases have successfully resisted pressures rang-



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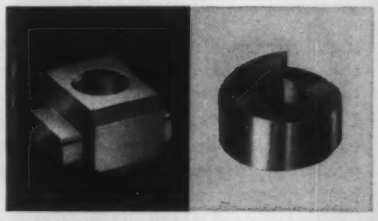

Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.

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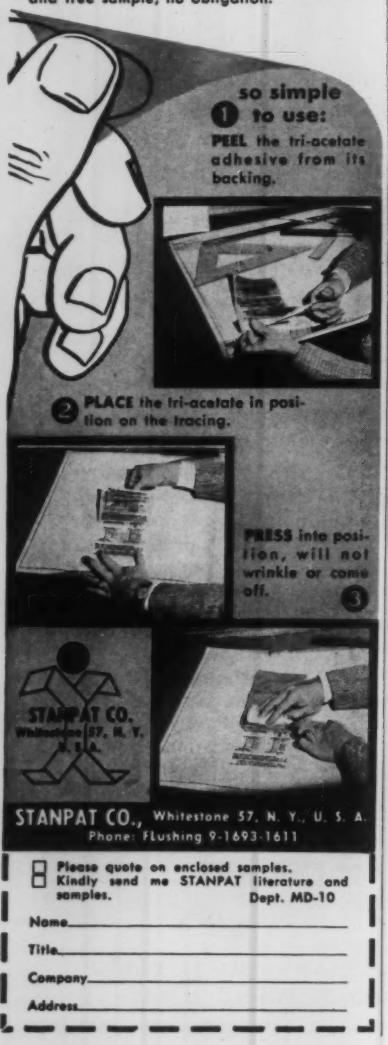
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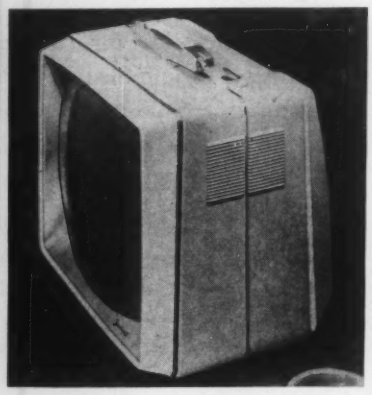
Circle 421 on page 19

FLAT TV-TUBE TREND shows up in new models. Above, new 110-degree deflection tube, made by Admiral Corp., measures 14¾ in. deep, while short-necked 90-degree tube is 17½ in. and old 70-degree tube is nearly 23 in. Company officials predict flat TV wall picture in less than 10 years. Below, portable by Philco needs only 8 x 14-in. table space, compresses antenna in handle of "slender-styled" cabinet. Uses 110-degree electrostatic picture tube with 155 sq in. of viewing area.



ing from 6000 to 35,000 psi. At the instant of firing, temperature inside the case is about 1900 F. Despite these sudden extremes, the cases emerge from the gun breech virtually unscathed. One case has been used in six test firings.

Plastic used by NOL is a polystyrene copolymer developed by Borg-Warner Corp. Named Cycolac, it is similar to material used in portable radio cabinets. Cycolac is characterized by a very low brittle point over a wide range of atmospheric temperatures. It readily meets NOL requirements of −65 to 165 F.

Propose Uniform Ratings For Air Moving Equipment

Manufacturers Seek Standard, Approved Laboratory Tests

CHICAGO—For the first time, specifiers and users will find air moving equipment described by a single code. Rating procedures will be set for equipment such as centrifugal, axial, and propeller fans and power roof ventilators by the Air Moving and Conditioning Association.

The program, in which leading U.S. and Canadian manufacturers will take part, includes:

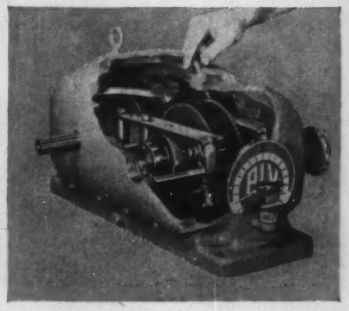
1. Inspection and approval of all test laboratories.
2. Performance ratings based on specified tests.
3. Contract with manufacturer to maintain prototype standards.

For a manufacturer to qualify his product, all tests must have been made in a laboratory inspected and approved by the Association. All manufacturers are required to sign a license, agreeing to maintain identical performance ratings of their product after testing. The

How Link-Belt P.I.V. provides stepless speed control

By employing a positive chain drive to transmit power, Link-Belt's P.I.V. (Positive, Infinitely Variable) variable speed drive provides instant and positive speed settings, with no perceptive loss of speed regardless of load. Stepless variation of any speed from maximum to minimum can be obtained instantly, even while operating at full load.

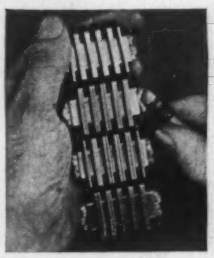
The chain which forms the "heart" of P.I.V. is a self tooth-forming chain consisting of a series of overlapping steel laminations which serve as teeth and are free to move from side to side, singly or collectively (see below). This ingenious chain fits into radially grooved wheels (see below) which have teeth cut at a constant depth but of increasing width toward wheel periphery.



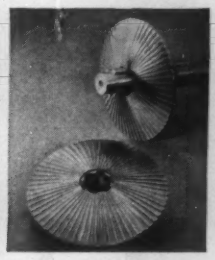
P.I.V.'s are compact, permitting installation as either a separate unit or as a built-in part of the driven machinery. Exceptional application flexibility can be accomplished by incorporating both motor and helical gear sets integrally with the P.I.V. drive.

By means of pneumatic, electronic, hydraulic or mechanical controls, P.I.V.'s can be used to synchronize machine components or complete machines with a precision matched by no other method. Whether these processes involve tension, volume, synchronization, winding speeds, moisture content, product thickness or similar requirements, these controls sense variations quickly and compensate for change through the P.I.V. before product quality is affected.

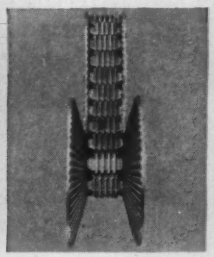
These unique P.I.V. drives are built in a wide range of sizes and assembly types, in capacities from ½ to 25 h.p.



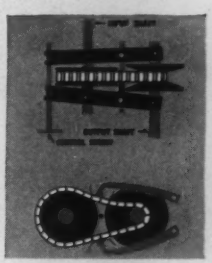
Self tooth-forming chain consists of overlapping steel laminations serving as teeth.



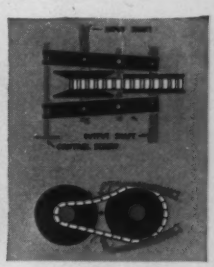
Teeth on radially grooved wheels provide grip for self tooth-forming chain.



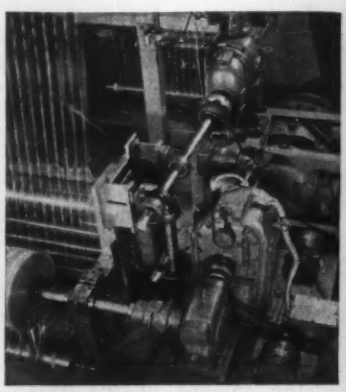
Chain teeth engage wheels to provide a positive chain drive to transmit power.



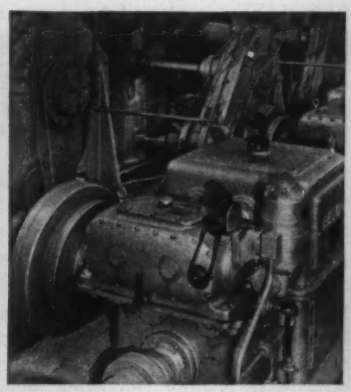
Maximum speed setting of the grooved wheels produces high speed at output shaft.



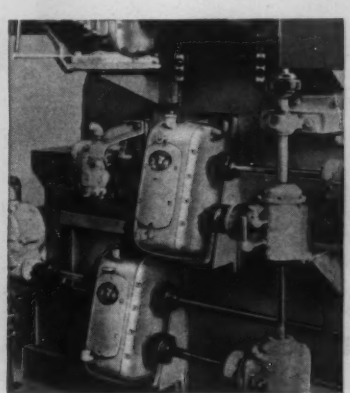
Minimum speed setting of the grooved wheels produces low speed at P.I.V. output shaft.



PRINTING—P.I.V.'s on windup and dryer rolls prevent tension build-up on press running cellophane sheet.



PAPER MAKING—P.I.V. with remote control lets operator control draw on differential drive paper machine.



TEXTILES—P.I.V.'s on rayon spinning machine control thread denier and speed of viscose metering pumps.

BOOKS 2274 and 2349 describe P.I.V. drives and controls, respectively. Get your copies from your nearby Link-Belt office.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,318

right to identify products with the AMCA code will be withdrawn for any violation of the license agreement. Performance ratings, issued only in accordance with tests in approved laboratories, are subject to spot checks by the Association.

Target date for completion of monumental job of inspecting and qualifying test laboratories in the U. S. and Canada is January, 1958.

ELBOLIFT, developed by Automatic Transportation Co., is claimed to be the first high-lift fork truck without a mast. Compensating linkages permit loads to be lifted vertically while retraction of lifting arms, pictured above, maintains stability during lifting. Loads can be tilted to either side, forward or backward. Capacity of the new electric truck ranges from 12,000 to 15,000 lb; maximum lifting height is 10 ft.

Single Aero Instrument Does Work of Four

BURBANK, CALIF.—Despite basic laws of physics, Lockheed engineers have caused two or more objects to occupy the same space at the same time. Spurred, no doubt, by the axiom that associates necessity and invention, they have built a single mechanism that combines the different and unrelated functions of four others.

Basically a two-purpose antenna, the new device also operates as an airspeed indicator and an emergency barrier arrester. It is located under the nose of the Navy T2V-1 SeaStar jet trainer at a spot determined best for the antenna of the pilot's command radio, the antenna of the Tacan navigation unit, the airspeed pitot tube, and the emergency arrester. If installed separately, each of the four would interfere with the others.

The antenna is 8 in. long, 5 in. wide, 1½ in. thick. The pitot tube

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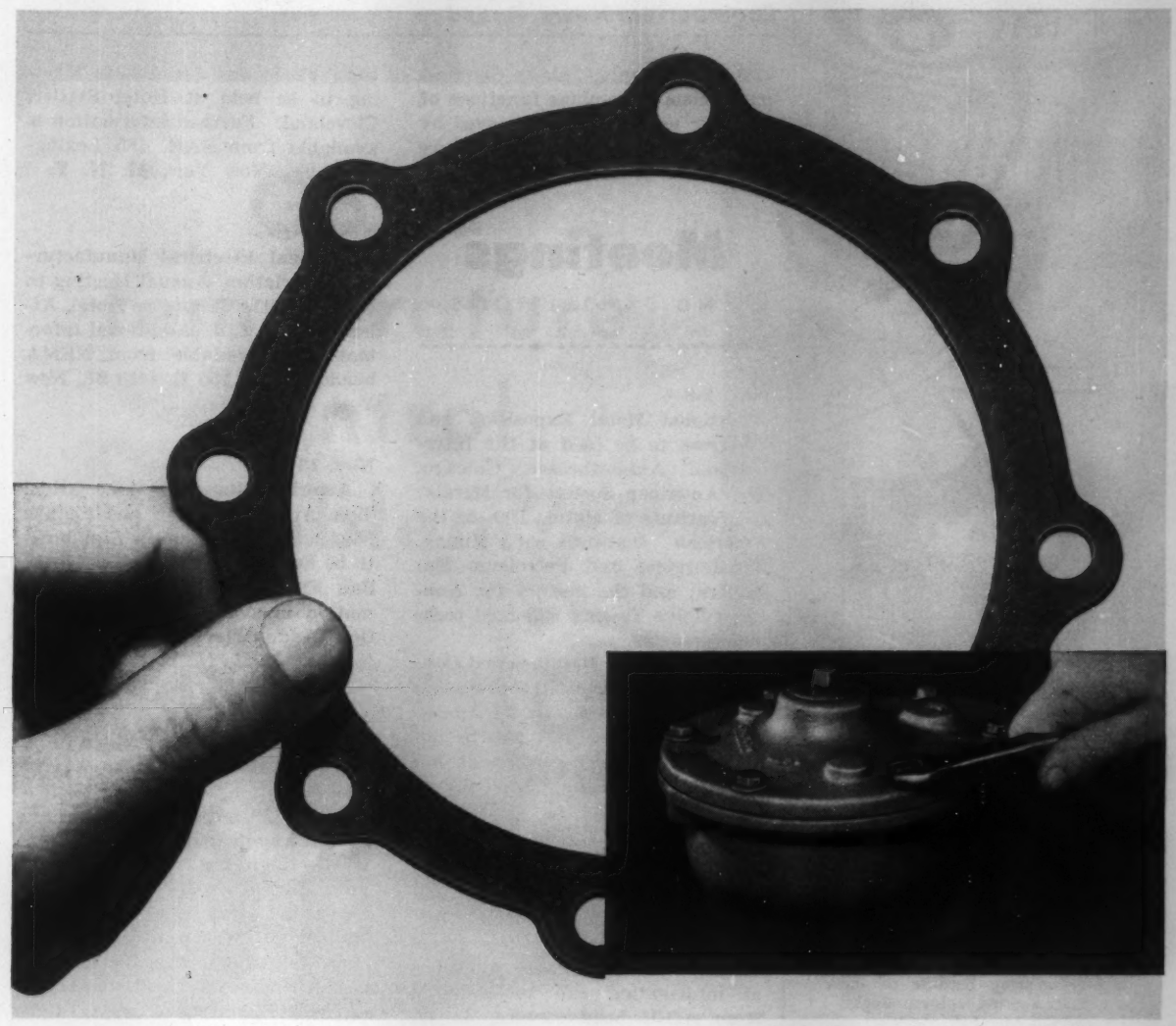
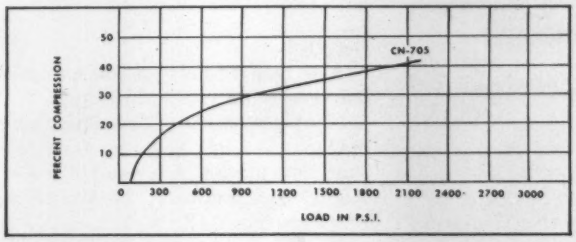
Circle 423 on page 19



Accopac fiber gasket seals hot oil at low flange pressures

Armstrong CN-705 Accopac®—an improved beater-saturated gasket material—will seal hot oil under relatively low pressures, even where flange temperatures go as high as 300° F. Under these conditions, ordinary plant-fiber materials often shrink and leak because their saturant is removed by the leaching action of the hot oil.



CN-705 delivers this kind of performance because of the patented way it's made. Cellulose fibers and finely ground cork are combined with a non-volatile nitrile rubber binder. The result is a strong, uniform sheet, with a compressibility range that makes it ideal for sealing minor imperfections on cast flanges.

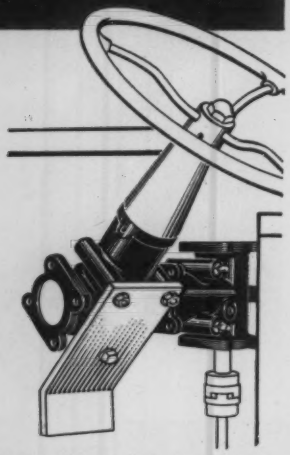
The wide Accopac line includes materials designed for practically every fiber sheet gasket application. For more information, write Armstrong Cork Company, Industrial Division, 7010 Dean Street, Lancaster, Pa.

Armstrong ACCOPAC

. . . used wherever performance counts

Circle 424 on page 19

ANGLgear® solves steering linkage problem



Simplified drawing based on photo shows ANGLgears used as steering linkage on John Morrell Co. Mor-Lift fork truck. ANGLgears adapt easily to different steering column angles of various Mor-Lift models.

In designing steering linkage for its Mor-Lift fork trucks, John Morrell Mfg. Co., Elgin, Ill., faced a problem of transmitting rotary motion through two 90° angles. Costwise, standard bevel-gear units were indicated. However, Morrell engineers also needed the design flexibility of custom gearing because of the different steering column angles of varjous Mor-Lift models.

Two standard 5 hp ANGLgears finally solved the problem. Their compactness and 4-way mounting feature made them easily adaptable to any steering column angle. This eliminated the cost of custom gearing and saved engineering time and expense.

Perhaps ANGLgear can solve a 90° drive problem for you. Designed for manual or power operation, ANGLgears come in ⅓ to 5 hp sizes, with 2- or 3-way shafting and 1:1 or 2:1 gearing.

See our literature in Sweet's Product Design File or contact your local distributor.

AIRBORNE®

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY

Circle 425 on page 19

is 3⅞ in. long. This is the first mechanism to combine functions of the four noted and is approved by the Navy as a standard feature of SeaStar trainers.

Meetings

AND EXPOSITIONS

Nov. 2-8—

National Metal Exposition and Congress to be held at the International Amphitheatre, Chicago. The American Society for Metals; the Institute of Metals Div. of the American Institute of Mining, Metallurgical and Petroleum Engineers; and the Society for Non-Destructive Testing will hold technical sessions.

Second World Metallurgical Congress will be held in conjunction with the Metal Show. Information on both meetings can be obtained from ASM headquarters, 7301 Euclid Ave., Cleveland 3, Ohio.

Nov. 4-6—

American Institute of Electrical Engineers. Machine Tool Conference to be held at the Hotel Schroeder, Milwaukee. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Nov. 4-6—

Society of Automotive Engineers Inc. Transportation Meeting to be held at Hotel Statler, Cleveland. Additional information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

Nov. 5-6—

Society of Automotive Engineers Inc. Diesel Engine Meeting to be held at Hotel Statler, Cleveland. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

Nov. 6-8—

Society of Automotive Engineers Inc. Fuels and Lubricants Meeting to be held at Hotel Statler, Cleveland. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Nov. 11-15—

National Electrical Manufacturers Association. Annual Meeting to be held at the Traymore Hotel, Atlantic City, N. J. Additional information is available from NEMA headquarters, 155 E. 44th St., New York 17, N. Y.

Nov. 13-15—

American Standards Association. 39th Annual Meeting and Eighth National Conference on Standards to be held at the St. Francis Hotel, San Francisco. Additional information is available from association headquarters, 70 E. 45th St., New York 17, N. Y.

Nov. 18-20—

Conference on Magnetism and Magnetic Materials to be held at the Sheraton-Park Hotel, Washington. Conference is sponsored by the American Institute of Electrical Engineers in co-operation with the American Physical Society; the American Institute of Mining, Metallurgical and Petroleum Engineers; the Institute of Radio Engineers; and the Office of Naval Research. Further information is available from L. R. Maxwell, U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md.

Nov. 18-21—

Air Conditioning and Refrigeration Institute. Tenth Air Conditioning and Refrigeration Exposition to be held at the International Amphitheatre, Chicago. Additional information can be obtained from R. H. Israel, Virginia Smelting Co., West Norfolk, Va.

Dec. 1-6—

American Society of Mechanical Engineers. Annual Meeting to be held at the Statler and Sheraton McAlpin Hotels, New York. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

Circle 426 on Page 19→

Got a temperature control problem?

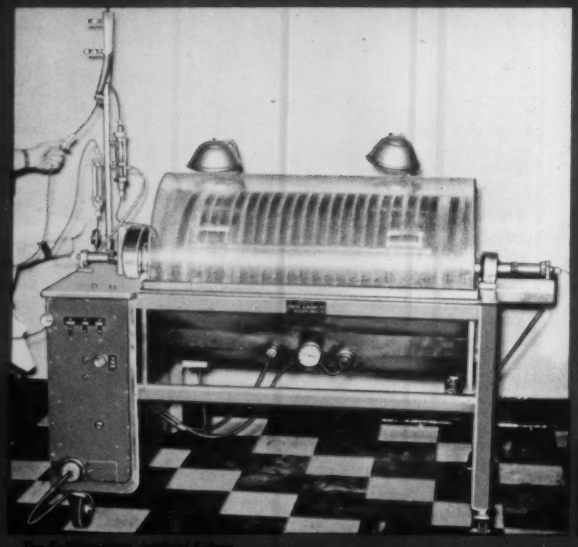
Fenwal

Tell you what a THERMOSWITCH® unit will do . . .

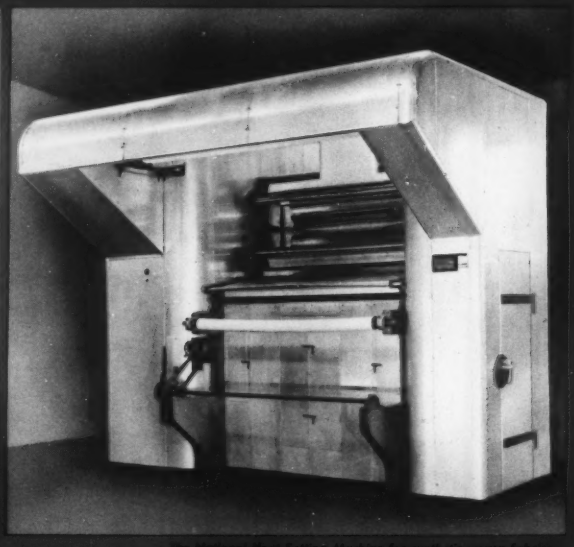
With Fenwal THERMOSWITCH® Units YOUR EQUIPMENT WILL...

- **Run at Faster Speeds** with increased output because of more precise temperature control. The inherent sensitivity of a Fenwal THERMOSWITCH unit is 1/10 of one degree Fahrenheit. Enjoy this competitive advantage!
- **Require Less Maintenance.** A Fenwal THERMOSWITCH unit has ten times as much resistance to vibration as ordinary thermostats. It has military ruggedness to resist shock to 100 G's. And it's tamper-proof!
- **Have Increased Flexibility.** Fenwal THERMOSWITCH units have a range of 700° F... three to five times that of ordinary thermostats. Open up new markets with this feature!
- **Have Longer Life.** Fenwal THERMOSWITCH units consistently provide one-half million or more cycles of precision temperature control. Cost is surprisingly low... not more than 2¢ per thousand cycles.
- **Have Reduced Assembly Costs.** All Fenwal THERMOSWITCH units fit a ⅝" hole, the cheapest machining operation. They're the same size as standard cartridge heaters!

for example...



The Kolff-Brigham Artificial Kidney



The National Reel Setting Machine for synthetic woven fabrics

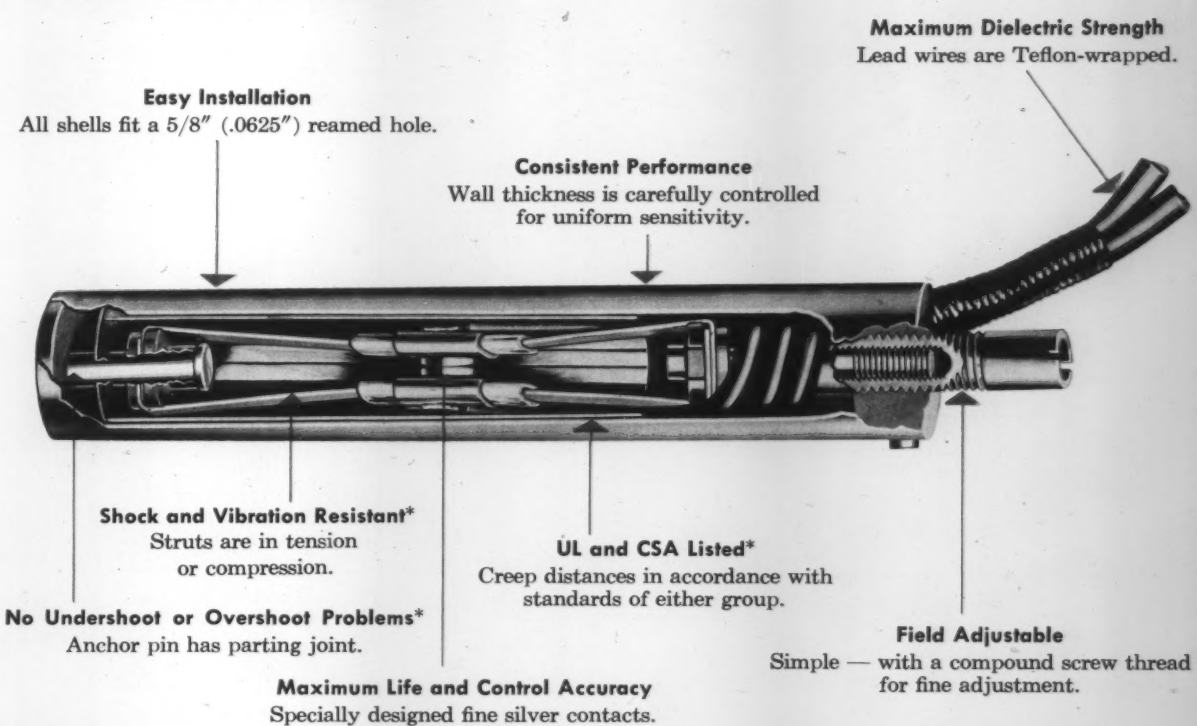
From Delicate Medical Equipment to Rugged Production Machinery

Fenwal THERMOSWITCH units are being used in countless applications.

Here's why Fenwal THERMOSWITCH® units provide such advantages

The activating control element is a single-metal shell that expands or contracts instantaneously with temperature change, making or breaking the totally-enclosed electrical contacts. The shell is the temperature-sensing element. There are no heat transfer paths as in ordinary thermostats.

SERIES 17000 BASIC DESIGN*


Maximum Dielectric Strength
Lead wires are Teflon-wrapped.
Easy Installation
All shells fit a 5/8″ (.0625″) reamed hole.
Consistent Performance
Wall thickness is carefully controlled for uniform sensitivity.
Shock and Vibration Resistant*
Struts are in tension or compression.
No Undershoot or Overshoot Problems*
Anchor pin has parting joint.
UL and CSA Listed*
Creep distances in accordance with standards of either group.
Field Adjustable
Simple — with a compound screw thread for fine adjustment.
Maximum Life and Control Accuracy
Specially designed fine silver contacts.

*TENSION TYPE ILLUSTRATED

Way ahead of ORDINARY THERMOSTATS
Only FENWAL THERMOSWITCH® units offer . . .

- **Quick Reaction** — four to nine times as fast
- **Narrow Temperature Differential** — one-twelfth to one-eighteenth as great
- **Vibration Resistance** — one-tenth to one-eighteenth as much shock-sensitivity
- **Uniform Sensitivity** — throughout the operating range

Name your problem!

Chances are we can name a Fenwal THERMOSWITCH® unit to solve it!

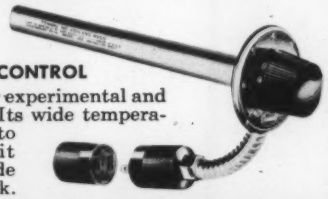
There's a Fenwal sales engineer ready to apply one of 25000 THERMOSWITCH unit variations to your particular heat control problem. Here are just a few . . .

STANDARD TYPE

SERIES 17000
CARTRIDGE
THERMOSWITCH CONTROL

Easily inserted in reamed hole in metal blocks and other solids.

EXPERIMENTAL TYPE



SERIES 17500
ALL-PURPOSE
THERMOSWITCH CONTROL

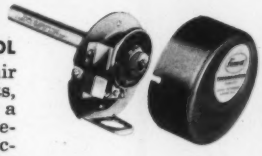
Generally used for experimental and laboratory work. Its wide temperature range (−100 to 600° F) makes it useful in a wide variety of test work.

FLUID IMMERSION TYPE

SERIES 17100
HEX HEAD
THERMOSWITCH CONTROL

Easily inserted directly into fluid by mounting in a tapped hole in container wall.

AIR CONTROL TYPE



SERIES 17700
JUNCTION BOX AIR
THERMOSWITCH CONTROL

Ideal for the control of air temperatures in air ducts, ovens, driers, etc., where a conduit junction box is required to facilitate electrical wiring. Available for fluid immersion also.

SURFACE MOUNTING TYPE

SERIES 17300
FLANGE HEAD
THERMOSWITCH CONTROL

The three tapped holes allow this unit to be mounted against any flat surface with proper size screws. A dial and knob as well as flexible lead wires can be attached.

CLOSED SYSTEM TYPE

SERIES 18000
COUPLING HEAD
THERMOSWITCH CONTROL

Generally used in closed liquid or gas systems by direct insertion in the medium to be controlled.

Write for a free booklet (MC-135) containing complete specifications on Fenwal THERMOSWITCH units.

Fenwal

INCORPORATED

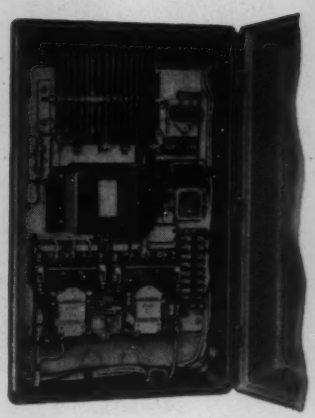
9-57 MC157 Printed in U.S.A.

1911 Pleasant Street Ashland, Massachusetts

CONTROLS TEMPERATURE . . . PRECISELY

IMPROVE MACHINE TOOL PERFORMANCE

—with Westinghouse components ...ready today

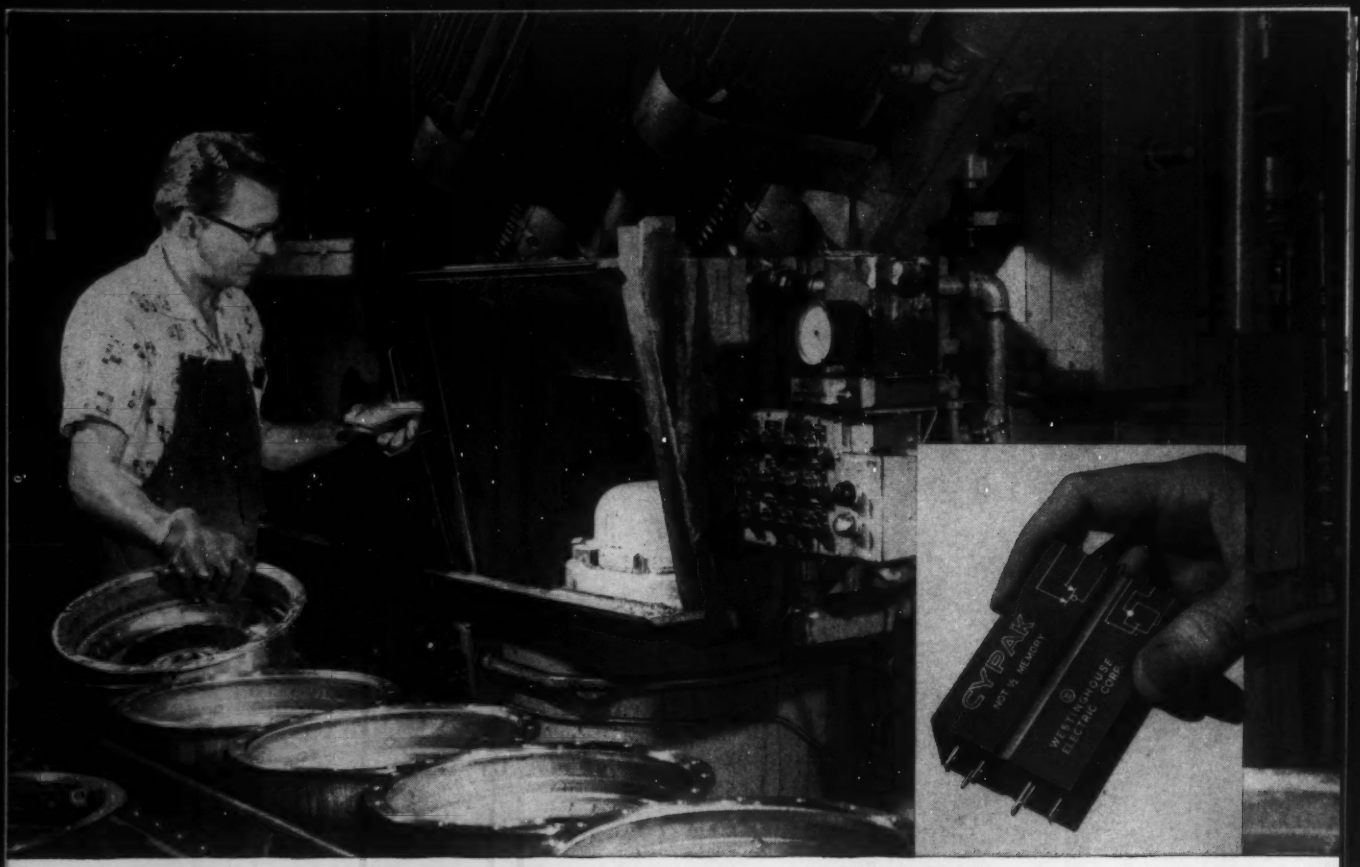


Stamping press performance improved at this plant when they used Westinghouse DYNAC braking control to reduce stopping time 95 percent.

MP-3057-1

YOU CAN BE SURE...IF IT'S Westinghouse

Circle 601 on page 19



Westinghouse Cypak static control reduces maintenance costs in form-grinding automotive transmission parts.

THESE COMPONENTS OFFER IMMEDIATE ANSWERS

...for more dependable operation

...for quicker stopping...for faster duty cycles

You don't have to wait for electrical answers in making machine tool improvements or modifications. Outstanding design and improvement in Westinghouse control components, systems and drives help designers and their customers to act now.

For example, *Westinghouse DYNAC® braking control*, cover photo, reduces press stopping time 95 percent. The eight minutes it previously took to stop the heavy flywheel on this press have been cut to just 24 seconds with DYNAC. This operation is now getting the fastest, smoothest stops possible to increase production.

Cypak static control*, above, has already outlasted conventional relays previously used on form grinders at a large automobile manufacturer's plant. No down time for control maintenance has been necessary on this highly repetitive operation in over 17 months.

*Trade-Mark

Westinghouse Life-Line® "H" Motors, right, make possible faster, smoother reversing cycles to save production time. Westinghouse reduced armature inertia up to 55 percent and increased commutating ability 35 percent to provide in the Life-Line "H" Motor the fastest d-c motor response available to improve machine tool performance.

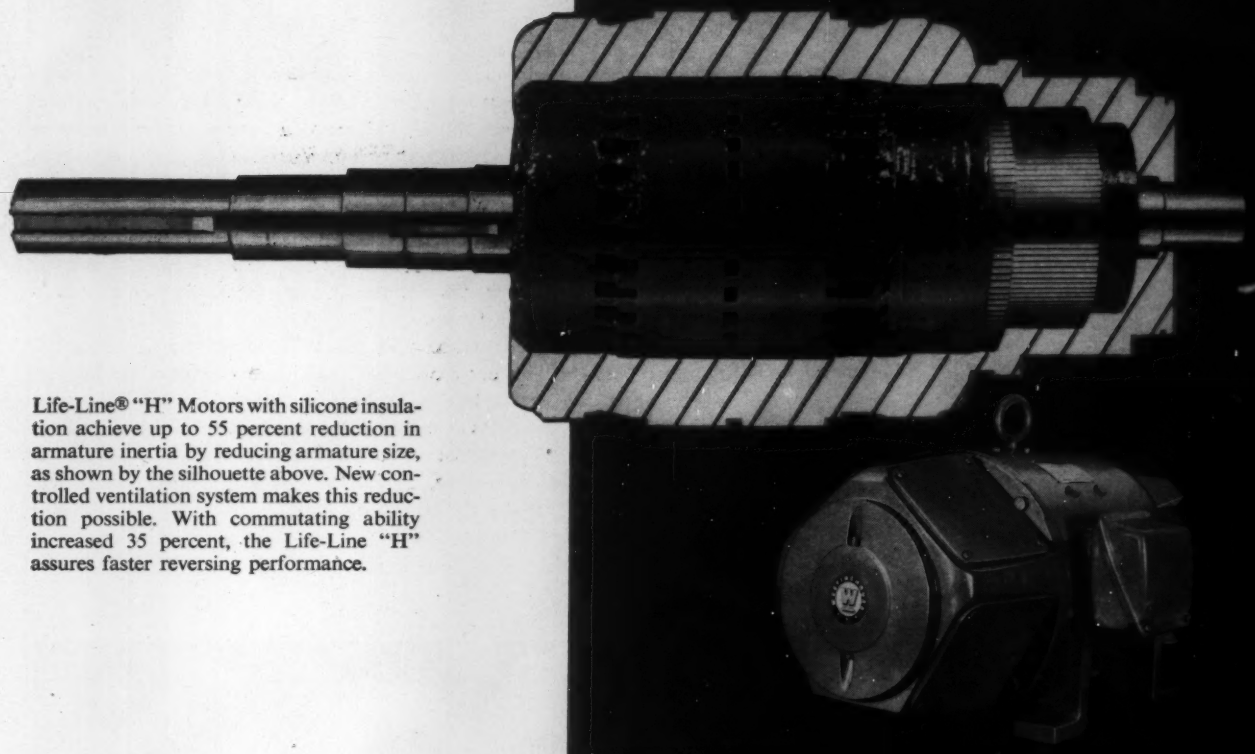
Westinghouse right-angle gearmotor, right, delivers up to 195 percent more torque capacity than conventional single-reduction worm gearmotors between 9:1 and 60:1 speed reduction ratios. It's the result of more efficient, double-reduction gear train. You'll find Westinghouse packaged motor-reducer drives offer rugged dependability, too, for improved machine performance.

Developments like these help you design and build machine tools that answer your customers' needs for increased productivity at lower cost. Whatever the function you want performed . . . sensing, transmitting, recording, computing, control or driving . . . think of Westinghouse components first!

MP-3057-2

YOU CAN BE SURE...IF IT'S Westinghouse

Circle 602 on page 19

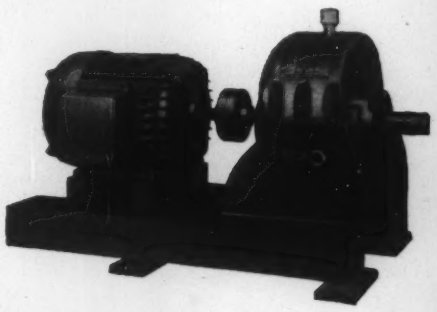


Life-Line® "H" Motors with silicone insulation achieve up to 55 percent reduction in armature inertia by reducing armature size, as shown by the silhouette above. New controlled ventilation system makes this reduction possible. With commutating ability increased 35 percent, the Life-Line "H" assures faster reversing performance.

Push-lite pushbuttons combine the functions of both a pushbutton and indication light in one unit. One push transmits the signal and energizes the indicating light. Push-lites are oiltight — part of the complete Oil-Tite* line of 1,500,000 pushbutton control arrangements available from stock.

*Trade-Mark

Either Westinghouse gearmotors or packaged motor-reducer drives save design time with a wide selection in horsepower, speed ratios, direction of power take-off, mounting and coupling methods. MP-3057-3



Circle 603 on page 19

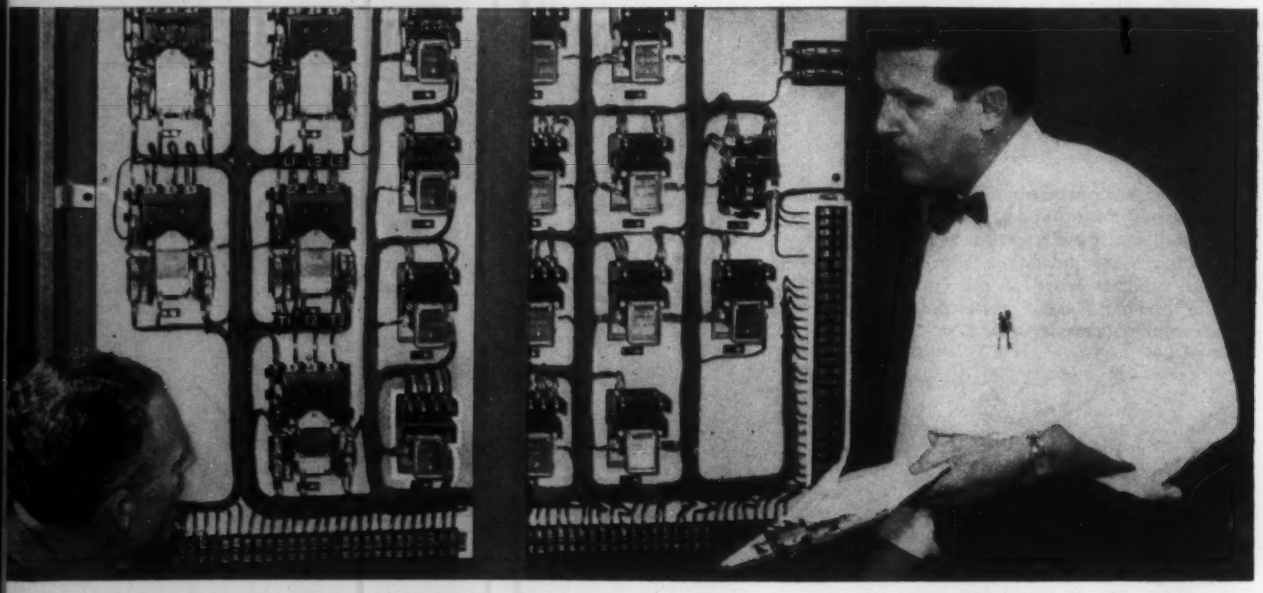
WESTINGHOUSE SERVICES AND FACILITIES ARE FLEXIBLE

HELP YOU FROM DESIGN BOARD TO TEST FLOOR

Add experienced manpower to your machine tool projects by simply calling your local Westinghouse representative. Whether you have a problem in drive system design, in component development or in manufacture and assembly, Westinghouse facilities provide economical ways to get the answer on schedule.

Westinghouse research . . . field engineering service . . . local manufacturing and repair plants . . . renewal parts stocks . . . are all ready to extend you service in any situation.

And when you select Westinghouse components, your customers will recognize electrical leadership. You'll benefit from one-supplier responsibility for products of outstanding quality, backed by more than 70 years of electrical experience. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. MP-3057-4



YOU CAN BE SURE... IF IT'S Westinghouse

Westinghouse serves these O. E. M. industries

- Air conditioning
- Appliance
- Communications—electronic
- Electric apparatus
- Fan and blower
- Machine tool
- Materials handling
- Panelboard and switchboard
- Prime mover equipment
- Pump and compressor
- Miscellaneous machinery

. . . with these components

- Motors—gearmotors
- Adjustable-speed drives
- Gearing
- Controls—relays—circuit breakers
- Semiconductors
- Cypak*
- Magamp* magnetic amplifiers
- Rectifiers
- Heating elements—thermostats
- Transformers
- Instruments
- DYNAC® magnetic braking

*Trade-Mark

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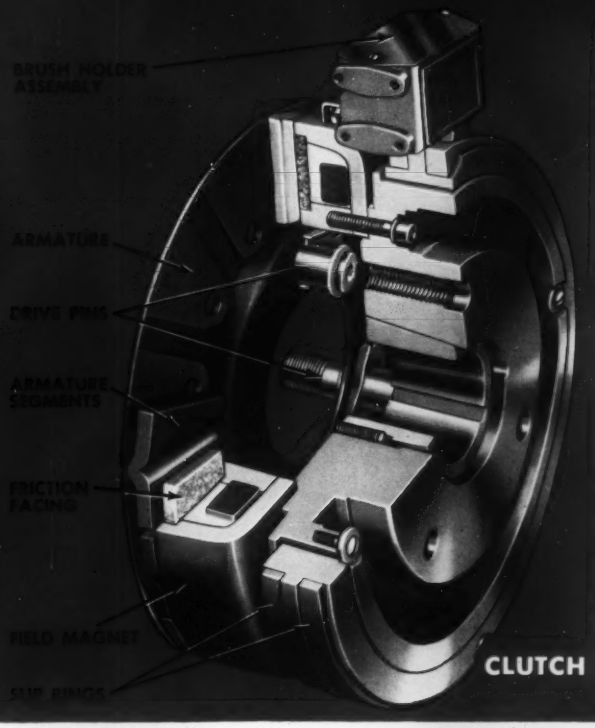
Circle 605 on page 19→

The New EATON Dyna-torQ

MAGNETIC-FRICTION CLUTCHES, BRAKES, CLUTCH-BRAKES, CLUTCH-COUPLINGS

Are the Accurate, Trouble-Free Means of Controlling Power and Motion in Modern Stop-and-Go Machines



CLUTCH

The Eaton Dyna-torQ electro-magnetic friction units include a number of unique design advancements which provide longer life and superior performance with less maintenance. Check the following important advantages:

1 **Extremely Rapid Response in Clutching and Braking**—makes Dyna-torQ units ideally suited to a wide range of manual and automatic cycling applications.

2 **Smooth, Shockless Engagement**—permits rapid operation without backlash or chatter.

3 **Highly Effective Cooling**—maintains lower operating temperatures; permits fast, repetitive actuation.

4 **Self-Adjustment**—automatically maintains proper clearance between armature shoes and field magnet.

5 **Simple, Accurate Control**—manual or automatic; may be had to operate on 110, 220, or 440 volt, 60 cycle, alternating current.

6 **Low Maintenance Costs**—result from unique design features and superior quality of construction, assuring long operating life and minimum down-time.

Eaton Dyna-torQ Clutches and Brakes are electrically operated, disc-type friction units having two basic components: a field magnet and an armature. Torque is transmitted as the magnet pulls the armature into engagement. Because the pull of the magnet is direct without intricate linkage, and the movement of the armature is slight, Dyna-torQ units are capable of extremely rapid response in clutching or braking.

Ask us to tell you how these Dyna-torQ units will fit your equipment.

BRAKE CLUTCH-BRAKE CLUTCH-COUPLING

WIDE RANGE OF SIZES AND CAPACITIES

Send for Illustrated Descriptive Literature

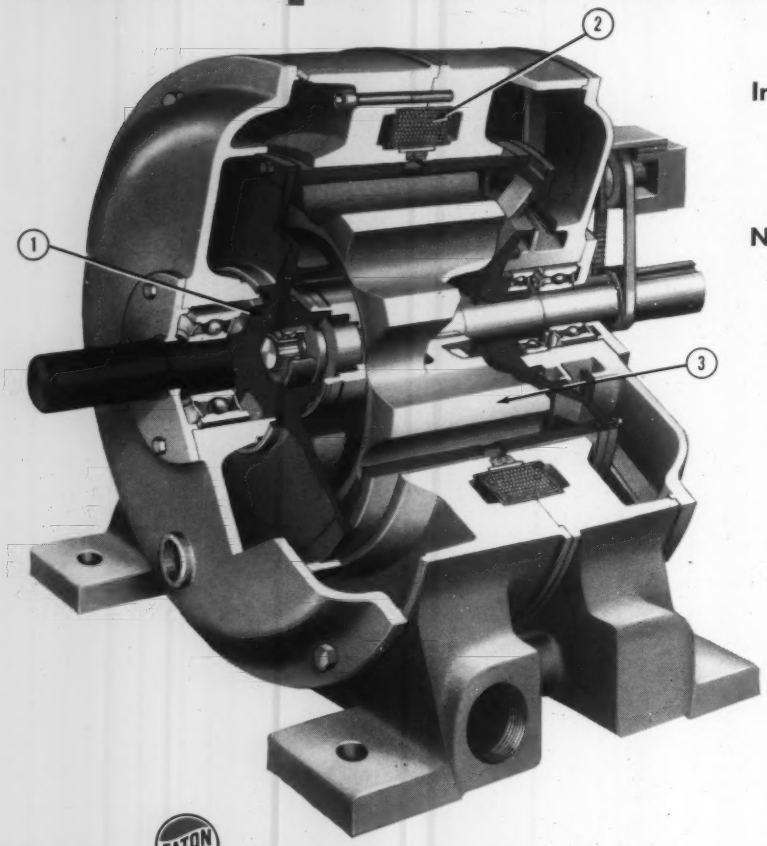
EATON

DYNAMATIC DIVISION

MANUFACTURING COMPANY

3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

Want Speed Control Like This?



Infinitely adjustable speed from AC power source

★

Wide speed range

★

No commutators, rings, brushes, or rotating coils

★

Instantaneous response

★

Remote control

★

Low power losses

★

Quiet, efficient operation

★

Simple construction

★

Low maintenance cost

1. Input Drum Assembly
2. Stationary Field Assembly
3. Output Rotor Assembly

EATON

DYNAMATIC®

Eddy-Current Equipment is the Answer!

Dynamatic Eddy-Current Drives, Couplings and Brakes are the solution to difficult speed control problems—in both original equipment and factory installations. Smooth, stepless acceleration and deceleration are achieved without mechanical contact between rotating members. Eddy-current braking provides cushioned, controlled stops. Dynamatic electronic or magnetic amplifier controls, in conjunction with these units, assure wide latitude in operating functions. For efficient, economical speed control, investigate Dynamatic Eddy-Current Equipment.

Send for
Illustrated Literature Describing
Dynamatic Eddy-Current Equipment

EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

Any similarity to a real-life company is purely intentional

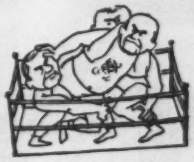
How does the master mechanic avoid tons of trouble?

When Flint N. Steele got his first job, he was determined to set the world afire. He had lots of spark — went on to big things. Today, he's one of the mighty over at Mighty Metals — master mechanic, to be exact.

MM rolls heavy tonnage in the course of a year. You never catch *them* with their plants down! And you never will, if Flint Steele has his way.

"No peanut-brittle part failure is going to foul up our production schedules!" is the way he puts it. Or words to that effect.

Now if you've ever seen a high-speed, continuous rolling mill, you know that it develops more impact, leverage, and load than a ringful of wrestlers. Several million instantaneous inch-pounds is nothing! (That's nothing?) Guarding against costly downtime is a mighty weighty problem indeed.



One way that Flint does it is by insisting on Ampco Metal at all critical points; for instance: (1) in the screw-down nuts; (2) in the screw-down worm wheel; (3) in the slippers (universal-joint bearing segments); (4) in the breaker blocks.

Ampco Metal is a uniform-quality copper-base alloy of such special yet sound structure that it withstands severe pressures and shock—and the abrasive action of powdered scale. It resists corrosion, so avoids the extra expense of special lubrication.

These characteristics make Ampco Metal especially suitable for use also in wearplates, pickling operations, and other production applications.

Where can Ampco save money for *you?* Talk it over with your nearby Ampco field engineer. And write for Bulletin 33 today. *Ampco Metal, Inc., Dept. MD-10, Milwaukee 46, Wisconsin (West Coast Plant: Burbank, Calif.)*

AMPCO®

AMPCO® METAL

The metal without an equal

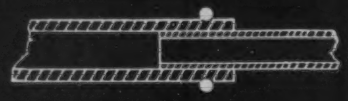
Circle 427 on page 19

FIRM GRIP NO SLIP

make hose connections faster with

EATON-RELIANCE

HOZ-FAS-NERS®



Production and maintenance men acclaim Eaton-Reliance Hoz-Fas-Ners for speeding up operations, cutting costs. Usable on rubber, plastic or fabric hose, they're always on the job — exerting continuous, uniform pressure at all points.

On assembly line operations, savings in time and motion are substantial with Hoz-Fas-Ners, compared with other type hose clamps. On service . . . removal and replacement of hose is greatly simplified. Hoz-Fas-Ners never need adjustment or retightening — they are vibration-proof and don't work loose.

Hoz-Fas-Ners can be installed quicker than other type clamps . . . no screws to turn, no nuts to put on, no preassembling. Hoz-Fas-Ners are fabricated from the highest quality alloy spring steel, and resist rust — your assurance of long life. Because of the round contours of the sections, the clamps have no sharp edges to cut into hose. They are re-usable — for additional savings.

Write for free Engineering Bulletin No. 1.

ALL STANDARD SIZES AVAILABLE

EATON

RELIANCE DIVISION
MANUFACTURING COMPANY
506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

Circle 428 on page 19

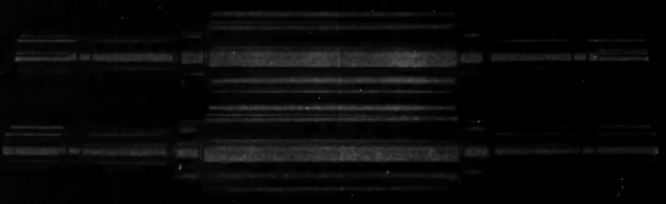
TSP Shaft Pinion
for Ore Unloaders

TSP Screw Down Screw and Nut for Blooming Mill

TSP Cone Crusher Gears

TSP Brake Wheels

TSP Leveller Rolls for Steel Mills



TSP Rolls for Steel Mills

TSP Crane Wheel Axles

TSP Pinions for Steel Mills

TSP Sprockets

TSP Edging Mill Bevel Gears

TSP Trunnion Rolls for Kilns

TSP Cable Drums for Cranes

TSP parts give your product a big competitive advantage

Wherever you use a "Tool Steel Process" hardened part as a component, replacement problems are virtually eliminated. They are guaranteed in writing to outlast, out-perform any competitive part in the same service. TSP hardened parts increase the efficiency and quality of your product, resulting in greater customer acceptance. Their phenomenally long wearing qualities are a result of our special hardening process. The file hard surface to the full depth of permissible wear gives maximum life. The core, refined for toughness and ductility, gives maximum strength. Note depth of hardness on gear tooth cross section.

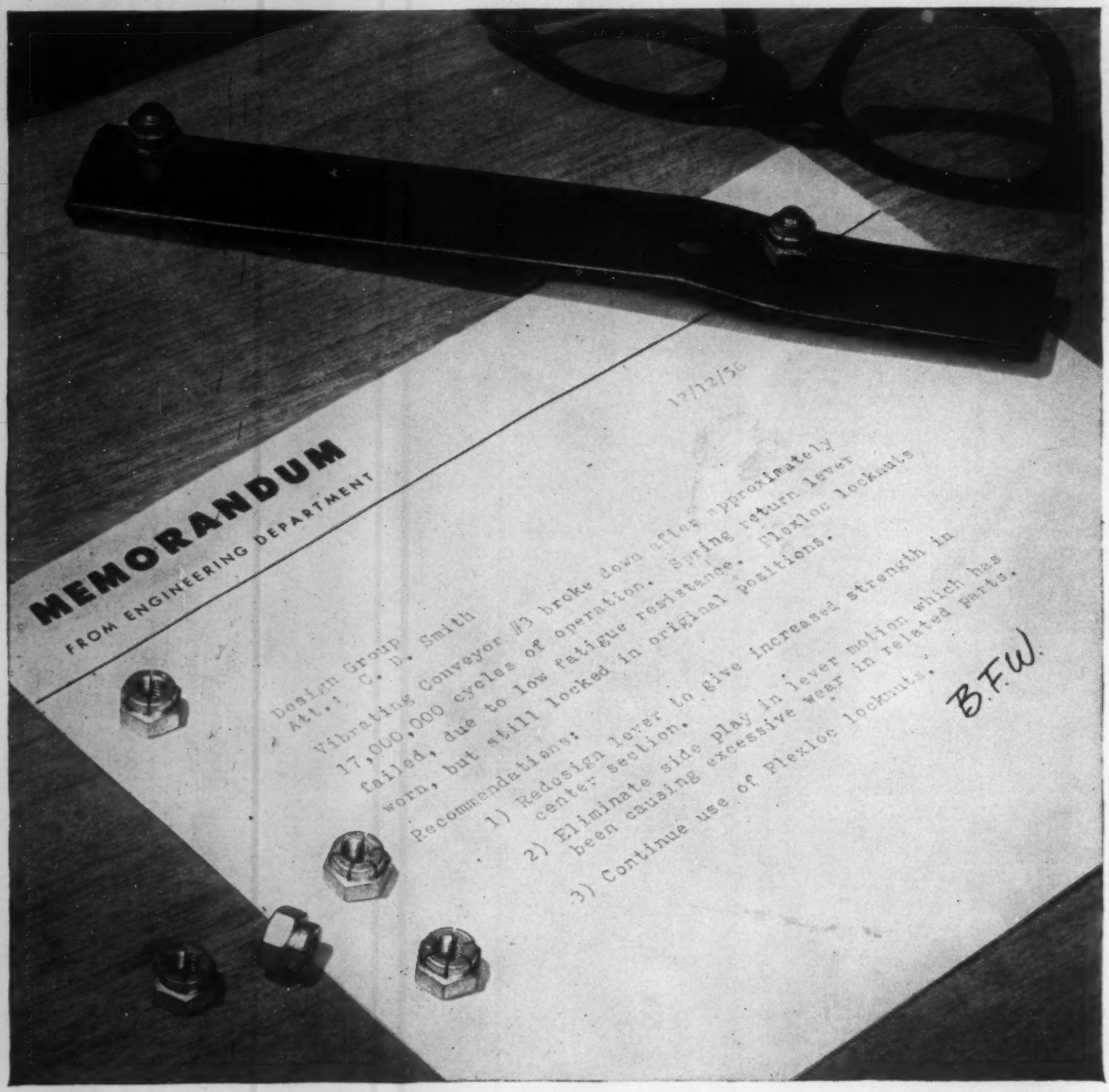
TSP hardened parts, a few of which are illustrated, are made to order from your blueprints, or to fit existing equipment. Gears made in sizes to 90" diameter. Other products up to 20,000 lbs. weight. Write for Bulletin 352 "Why Are They Called TSP Products", and complete information about TSP applications for your product.

THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO, U. S. A.

AD 1028

The Standard of Quality Since 1909 for Gears • Pinions • Rolls • Wheels and Other Hardened Products

Circle 429 on page 19


MEMORANDUM
FROM ENGINEERING DEPARTMENT
12/12/36
Design Group
Att.: C. D. Smith
Vibrating Conveyor #3 broke down after approximately
17,000,000 cycles of operation. Spring return lever
failed, due to low fatigue resistance. Flexloc locknuts
worn, but still locked in original positions.
Recommendations:
1) Redesign lever to give increased strength in
center section.
2) Eliminate side play in lever motion which has
been causing excessive wear in related parts.
3) Continue use of Flexloc locknuts.
B.F.W.

Why designers specify FLEXLOC self-locking nuts

Where products must be tough . . . must stand up under vibration, shock and abuse . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts as fasteners.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting spring tension in the flexible locking collars. And they are reusable: rough screw threads, repeated removal and replacement, frequent adjustments will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes and materials, to meet the most critical locknut requirements. Your authorized industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

We also manufacture precision titanium fasteners. Write for free booklet.

FLEXLOC® LOCKNUT DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

Circle 430 on page 19

4 OF THE MANY STYLES OF THE ONE-PIECE SEAMLESS DOOR KNOBS FABRICATED FROM RUGGED REVERE BRASS STRIP.

REVERE BRASS STRIP

Stands the Gaff!

The one-piece door knobs shown are drawn from a single blank of Revere Brass Strip, presenting an attractively smooth, unbroken surface without the need for seams or welds.

Because they are made by a unique procedure the manufacturer tells us that the brass must stand up under mighty rugged going, and that to produce the quality knobs they do, at an economical production level, the brass they use must have:

1. *Uniformity of gauge.*
2. *Absence of any sign of fracture or crimping when drawn.*
3. *Consistently correct grain structure to insure a smooth, flaw-free surface on the finished knobs.*

The manufacturer also tells us that Revere Brass Strip has been filling that bill, with utmost satisfaction, for some time.

Revere Brass Strip may be able to help *you* make a better product at less cost. You'll never know until you talk it over with one of our TA's (Technical Advisor). There's no obligation, of course. And such a discussion could save you a substantial sum of money. Such has been the case many, many times.

COPPER ★ BRASS ★ 18 01 ★ REVERE ★ ALUMINUM

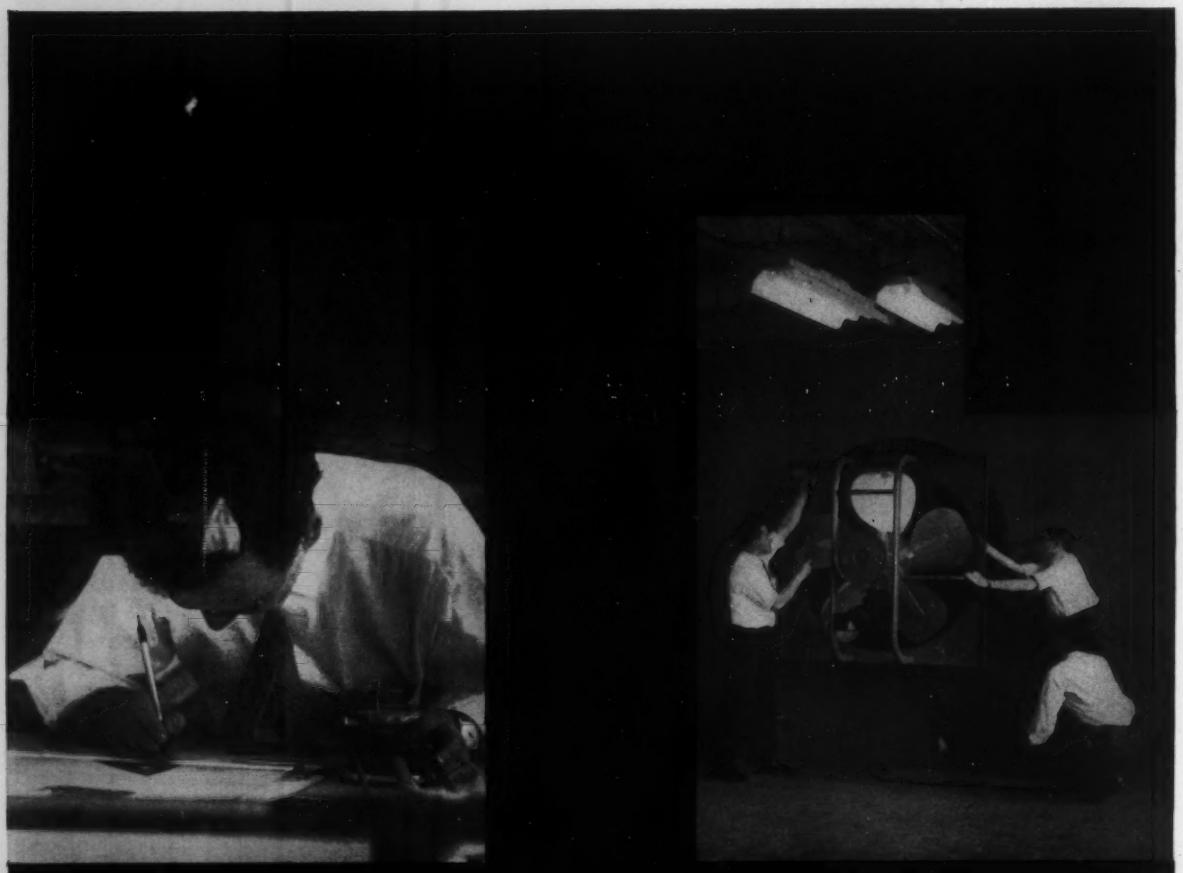
REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

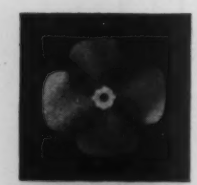
230 Park Avenue, New York 17, N. Y.

Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

Circle 431 on page 19



TAILORED FOR YOU TO A "T"



Torrington technology, tools and testing facilities are the finest in the world for tailoring air impellers specifically - and precisely - to your new product requirements.

These three T's of Torrington are the tangible assets of an unmatched experience in equipping the successful products of every major manufacturer in the air moving industry.

And the three T's of Torrington are yours for the solution of any problem relating to the moving of air.

Talk to Torrington!

THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

Circle 432 on page 19

USING

DU PONT ELASTOMERS

neoprene · Hypalon

in design

"Non-skid" neoprene reels help dye slippery synthetic fabrics

Gaskets of HYPALON unaffected by 2% ozone after two years' use

For two years, a large chemical firm has used gaskets of HYPALON in its ozone generators. Despite constant exposure to 2% ozone, not one gasket failed because of ozone cracking.

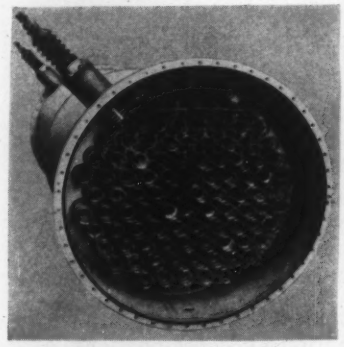
The ozonator is a steel shell packed with glass tubes. As dry oxygen passes through the tubes, it is converted to ozone by high-voltage electrical discharge. Each end of the shell is closed by a dished head sealed with a gasket of HYPALON.

Plastic gaskets too rigid

Plastic gaskets, which were formerly used in the generators, were unaffected by ozone, but took a permanent set under flange pressure. When a head was removed for routine maintenance the plastic gasket was too distorted to put back. Gaskets of HYPALON are reused.

Designing with HYPALON

HYPALON offers many additional advantages compared to other types of rubber. It resists strong oxidizing acids; can operate at temperatures from 250° F. to 350° F.; resists weather and sunlight. This Du Pont synthetic rubber can also be compounded in an unlimited range of stable colors. HYPALON offers extra long life and lower operating costs in jobs where conditions are severe. Just mail coupon for full information.



Gaskets made of HYPALON seal each end of this ozonator; they show no deterioration after two years in service.

Fluted neoprene bars show little wear after four years in dye machine. Dye bath may be acid or alkaline, oxidizing or reducing. Temperature is 200° F.

Mill uses neoprene to get needed traction for hauling fabric through dye bath

Chatham Manufacturing Co., of Elkin, N. C., used neoprene to solve an unusual problem in dyeing synthetic fibers. Long loops of the fabrics are dyed in stainless steel piece dyeing machines. Loops, often 100' long, are pulled through the dye bath by means of a reel. The slow rotation of the reel assures even dyeing over the full length of the goods.

The progress of the fabric depends entirely on friction between reel and loop. When several types of metal reels failed to produce enough friction to pull the smooth synthetic fabrics through the bath, Chatham designed special fluted neoprene bars for the reels. They provided adequate traction and ended the problem of slippage and uneven dyeing.

Chemical resistance important

Bars covered with natural rubber could have solved the traction problem but neoprene was chosen for its excellent chemical resistance. In dyeing various fabrics the dye bath may be acid or alkaline, oxidizing or reducing. Each dyeing cycle requires 3-5 hours at 200° F., and the dye machines operate 24 hours a day. Ordinary rubber just couldn't stand this treatment. Chatham's Superintendent of Dyeing, Mr. V. Caton, reports that neoprene has given excellent service for four years with little wear.

Neoprene's resistance to chemicals, heat and abrasion means long-term wear—and economy in many types of service. Mail coupon below for full details on how neoprene can work for you.

DU PONT
REG. U. S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc).*

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

☐ I am particularly interested in _____

☐ Send me a free copy of *The Du Pont Elastomers* (a review of properties of neoprene and HYPALON).

☐ Add my name to the free mailing list of the *Elastomers Notebook* (contains articles based on uses of Du Pont elastomers in industry).

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-10
Wilmington 98, Delaware

Name _____

Firm _____

Address _____

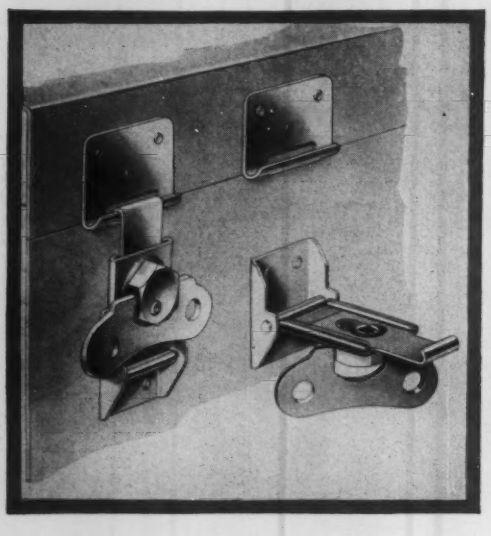
City _____ State _____

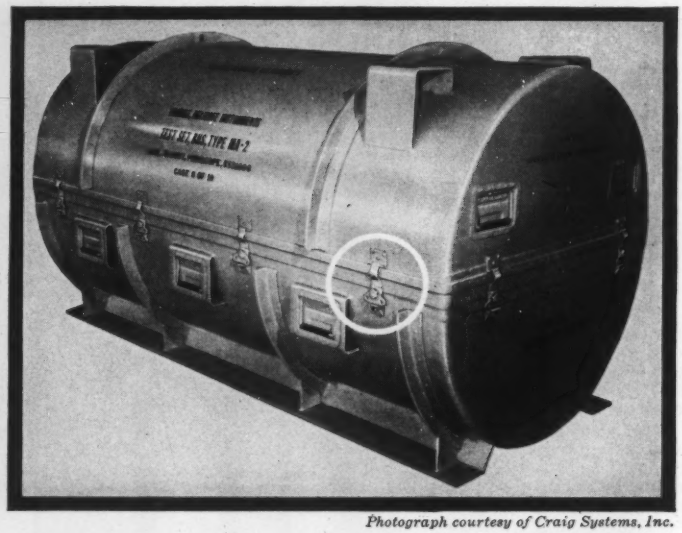
Circle 433 on page 19

Note—Commercial and Military Packaging Engineers:

Rugged LINK-LOCK

...your best answer to exacting closure problems





Photograph courtesy of Craig Systems, Inc.

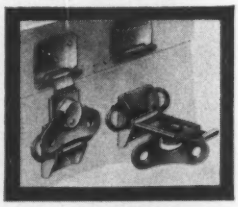
LINK-LOCK provides pressure-tight closure on this rigidly specified equipment container

Simmons LINK-LOCK provides quick opening and closing as well as impact-resistant dependability on transit cases manufactured by Craig Systems, Inc., Danvers, Mass.

The cylindrical Craig container above is gasketed and pressure-tight, and contains delicate electronic equipment. Twelve LINK-LOCK fasteners are used on this model.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque..... insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design...lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.

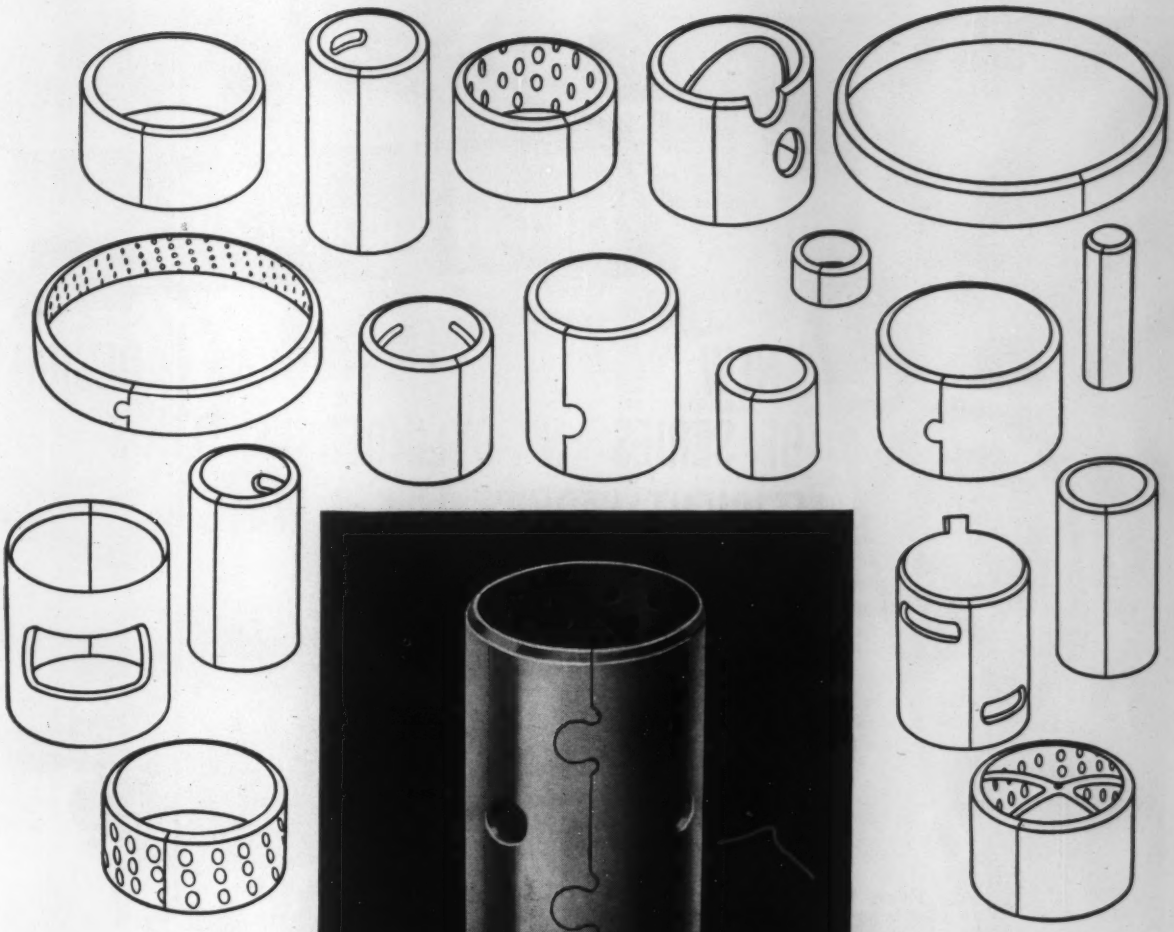


Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

Where does the versatile Simmons LINK-LOCK belong in your design? For complete information and specifications, send for the Simmons Catalog today. Samples and engineering service available upon request.

SIMMONS
FASTENER CORPORATION
1756 North Broadway, Albany 1, New York
QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK

Circle 434 on page 19



Solid bronze, steel or aluminum

Steel lined with bronze, babbitt or copper alloy

Plain or ball indented

Oil holes, grooves, slots, notches as required

Straight, clinch butt or special seams

Many lengths and diameters

Bearing Performance • Bushing Economy plus special design features

Savings in materials, time and labor are possible using bimetal or plain rolled split bushings. Bimetal bushings provide bearing load-carrying qualities. All offer economy through volume production. Uniformity and strength are established through controlled alloy quality and grain structure. Our method of manufacture also permits wide flexibility in design features. Complete engineering service. For details, address:

FEDERAL Mogul SINCE 1899

FEDERAL-MOGUL DIVISION

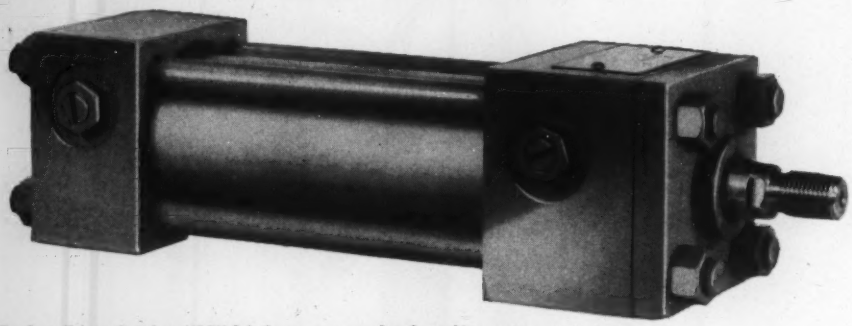
FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

Circle 435 on page 19

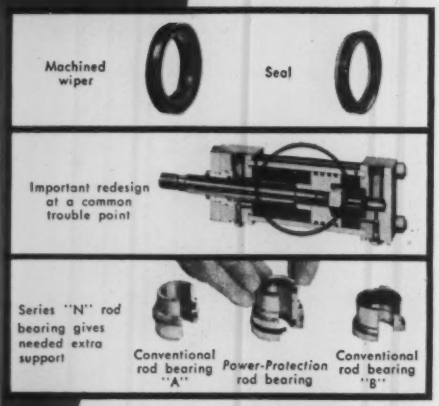
Can't be improved on?

NEW POWER-PROTECTION DESIGN OF SERIES "N" CYLINDERS EXTENDS EFFICIENT SERVICE LIFE 4 WAYS



Every Hydro-Line Series "N" high-pressure hydraulic cylinder is smoother operating and gives trouble-free, more efficient service for more high-speed cycles because it's the end result of a complete review of the design problem.

Bores 1-½ in. to 12 in. . . . 13 standard mounts . . . 2000-psi and higher operation


Machined wiper
Seal
Important redesign at a common trouble point
Series "N" rod bearing gives needed extra support
Conventional rod bearing "A"
Power-Protection rod bearing
Conventional rod bearing "B"

SELF-LUBRICATION OF ROD BEARING WITHOUT OIL LEAKAGE — this is made possible by the neoprene wiper and seal shown on the left. The flared lip of the seal, without mechanical holding against rod, permits a small amount of oil to cling to the rod and pass into the bearing for lubrication on the outstroke. Close-fitting machined inner edge of wiper eliminates leakage, wipes piston rod dry on the outstroke.

CLEANER INSTROKE — precision machining of the external edge of the neoprene wiper makes it an almost perfect barrier against dirt and air as the rod moves back inside the cylinder. Chances of scoring are minimized.

GROUND, HARD-CHROME-PLATED AND POLISHED PISTON ROD — the finish of the ground, hard-chrome-plated and polished piston rod not only makes it highly resistant to both scoring and corrosion, it also offers the perfect mating surface for the machined edges of the wiper. The combination of self-lubrication, dirt elimination, and the extreme hardness and smoothness of the rod surface gives you very important protection at one of the major trouble points in conventional cylinder designs.

BETTER ROD SUPPORT—Hydro-Line's "Power-Protection" design simplifies maintenance and gives extra rod support. Bearing "A" has its useful length reduced by cavity needed for 3-piece rod wiper assembly plus space for hat packing. Seal on bearing "B" is very close to rod wiper reducing bearing strength at critical outboard end.

Call your nearby Hydro-Line representative today — ask for demonstration of how *Power-Protection* design can give you longer trouble-free cylinder service life.

HL CYLINDERS

HYDRO-LINE MANUFACTURING COMPANY

5600 PIKE ROAD ROCKFORD, ILLINOIS

manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • booster cylinders

Circle 436 on page 19

Problem: To produce a rugged, dependable motor case for Sunbeam Mixmasters—in sufficient quantity to meet customer's need. Production cost must be low, to keep price competitive.

Solution: Working closely with Sunbeam, Stewart Die Casting engineers developed an intricate two-cavity die, consisting of slide, cores, and one loose piece—all held to extremely close tolerances. The result was a precision casting that can be produced economically with a minimum of rejects . . . a motor case that gives dependable, long-lasting service under all conditions.

Stewart found the solution and made delivery on time!

This is just one of many complicated die castings that Stewart has developed promptly . . . and has produced in quantity *at low cost.*

Nearly half a century of experience, plus unexcelled production facilities, enables Stewart to bring you fast, practical solutions to any die casting problem.

Whatever type of die casting you need—large or small, simple or intricate—you can count on Stewart for a quality job . . . completed and delivered on schedule.

Stewart **DIE CASTING**

Division of STEWART-WARNER CORPORATION

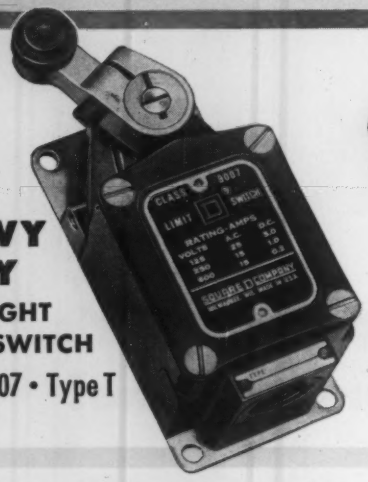
Chicago, Illinois: 4535 Fullerton Avenue • Bridgeport, Connecticut: 275 Warren Street

46 YEARS OF SERVICE TO INDUSTRY

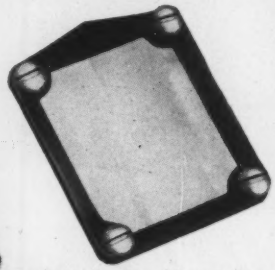
SQUARE D Limit Switches with– Features

–TO THOSE WHO BUILD MACHINES

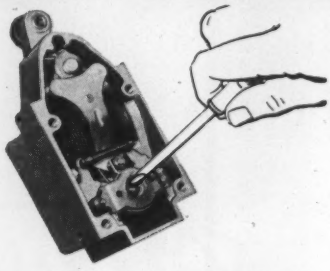
Square D limit switches have certain design features that warm the cockles of any machine builder's heart. You can spot the major ones in the panels below. Equally important is the customer's nod of approval when he sees the time-proven [D] nameplate on the limit switches that help control his new machine.



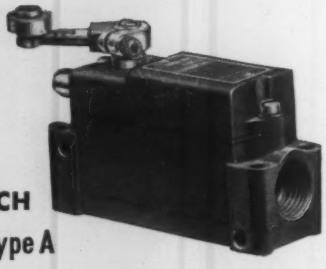
HEAVY DUTY OIL-TIGHT LIMIT SWITCH
Class 9007 • Type T



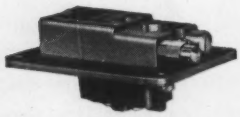
Instant visual inspection of mechanism through transparent plastic cover (optional). A tremendous time saver in multiple switch installations.



Eleven contact arrangements in one switch...and all you need to make the changes is a screwdriver!



SMALL **OIL-TIGHT LIMIT SWITCH**
Class 9007 • Type A



This small precision limit switch is available in three forms—basic contact mechanism, flush mounting and surface mounting. Both flush and surface mounting switches are available with varying lengths of roller arms and with rollers of different types and sizes. Also push rod operated *(shown above)* and in single unit or duplex construction.

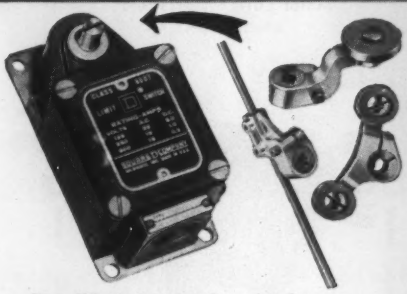
NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE

SQUARE D COMPANY

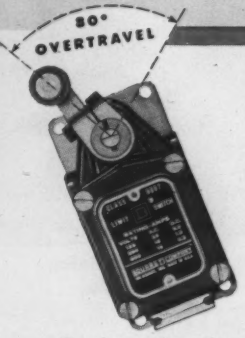
that Mean Plenty

...AND TO THOSE WHO BUY THEM

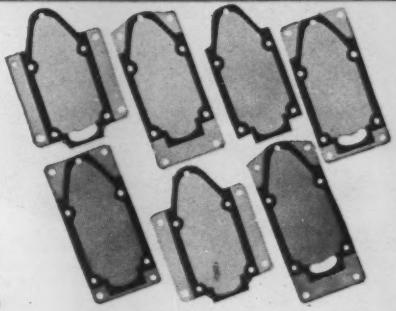
Just as you'd suspect, it's Square D's consistent performance and long life that appeals most to the men who buy and maintain the machines. But there are other advantages, too, having to do with versatility, easier installation and simpler maintenance. Some of the more important ones are illustrated below.



Simplified stocking because basic switches and a wide variety of lever arms are packaged separately. Moderate stock handles a multitude of combinations.



Continuously adjustable operating lever arms permit an infinite number of adjustments! Up to 80° overtravel reduces arm breakage.



Easy mounting and interchangeability through wide variety of base plates and side mounting holes.

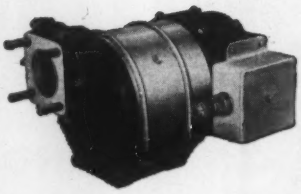
Roller arms are available in a wide range of designs and lengths.

Write **for Bulletin 9007** ... which gives the details of Square D's complete line of oil-tight limit switches. Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.

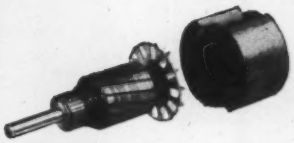
Everybody's Ahead with Square D!

Circle 438 on page 19

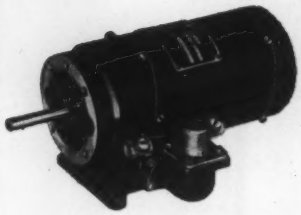
Army tank ventilating blower motor.



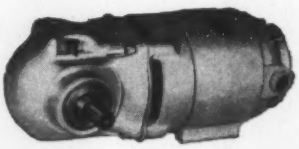
Hydraulic pump motor.



Motor parts for portable electric tools.



Aircraft pressurizing pump motor.



Motor with spiralled gear drive.

If you are interested in any of the above motors, write and we shall be glad to send full information.

WINNING HORSEPOWER
for your motor-driven product

With a Lamb Electric *specially engineered* motor you obtain the motor qualities which are important in winning acceptance for your product.

Exceptional performance and dependability are standard with Lamb Electric Motors, at no increase in cost, because they are "custom tailored" by personnel having many years of experience in this field.

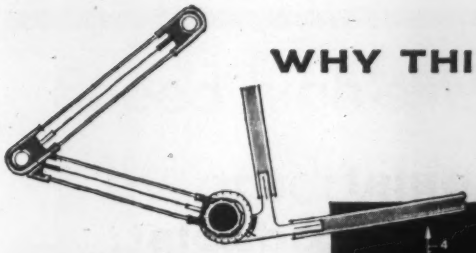
May we demonstrate these advantages for *your* new and redesigned products?

THE LAMB ELECTRIC COMPANY • KENT, OHIO
A Division of American Machine and Metals, Inc.
In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

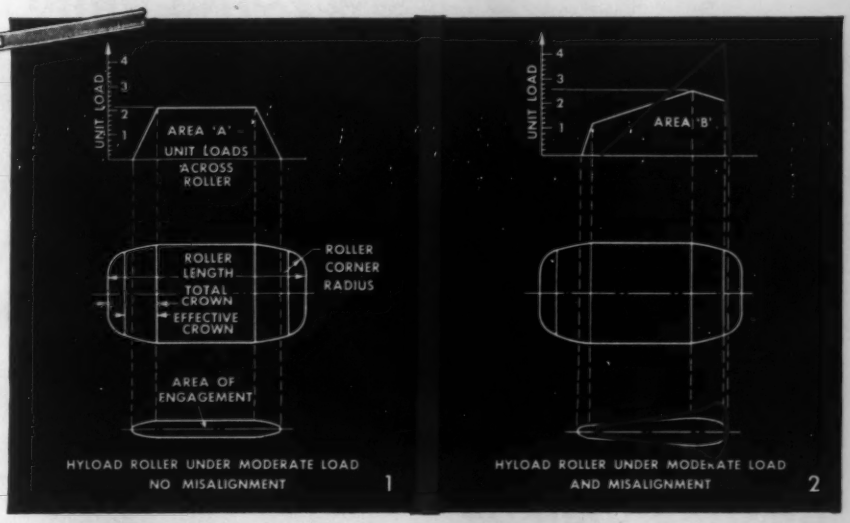
Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Circle 439 on page 19



WHY THINGS RUN SMOOTHER WHEN YOU SPECIFY HYATTS

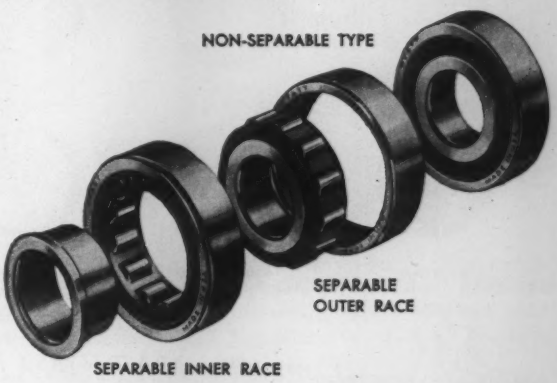


HY-LOAD ROLLER CROWNING MINIMIZES EFFECTS OF MISALIGNMENT—LENGTHENS BEARING LIFE

In any roller bearing, the design and quality of the rollers themselves vitally affect the performance of the entire bearing. The distribution of the load across the roller's full area of contact must be carefully controlled. End-loading and conditions of misalignment can seriously reduce the life of a roller bearing. How HYATT minimizes these effects is detailed at the right.

You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer. Hyatt Bearings Division, General Motors Corporation, Harrison, N.J., Pittsburgh, Detroit, Chicago and Oakland, California

The unit load on any roller is distributed axially in a uniform manner except at the ends where crowning has been provided. Figure 1 shows how the unit load drops off to zero at the ends of the area of contact. The summation of unit loads represented by area "A" is the total roller load. This same load under conditions of misalignment (Figure 2) must result in an area "B" equal to area "A"; but the maximum unit load is considerably greater and the misaligned bearing will therefore have a shorter life. However, if the same total load is applied to an uncrowned roller in a misaligned bearing, as shown in red, a much higher maximum unit load (area "C") results, and would reduce the life of the bearing. This demonstrates why HYATT Hy-Load Series Bearings with roller crowning run smoother and longer even under conditions of misalignment.



THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

GM GENERAL MOTORS

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

Circle 440 on page 19

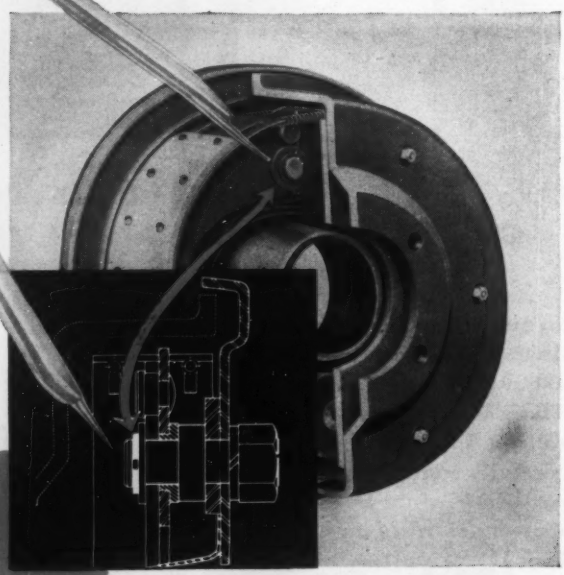
Opportunity for Designers...

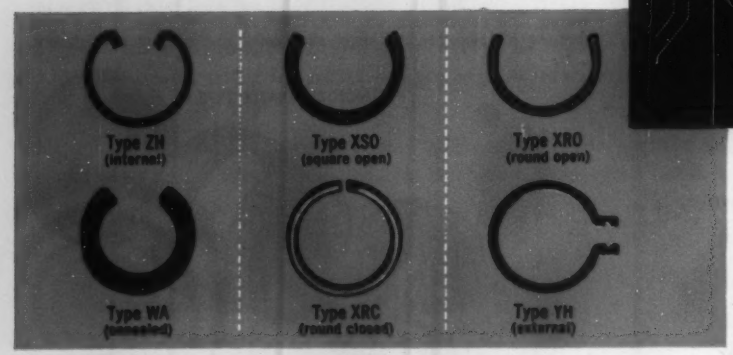
Cut your costs!
Improve your products!

NATIONAL
RETAINING RINGS

Here's how National Retaining Rings can Save Time and Money—

- **REDUCE WEIGHT**
- **SAVE MATERIALS**
- **SAVE SPACE**
- **SIMPLIFY ASSEMBLY**
- **REDUCE PRODUCTION OPERATIONS**





TYPICAL APPLICATION—

A 25% saving in assembly cost resulted when retaining rings were employed in this electric brake. Elimination of a nut, the threading of one end of shaft and reduction of 8" in the length of an anchor pin effected additional important cost reductions.

Consult a NATIONAL Engineer— He has the facts on thousands of successful applications and will be happy to discuss your specific design problems at your convenience. Just call or write, today!

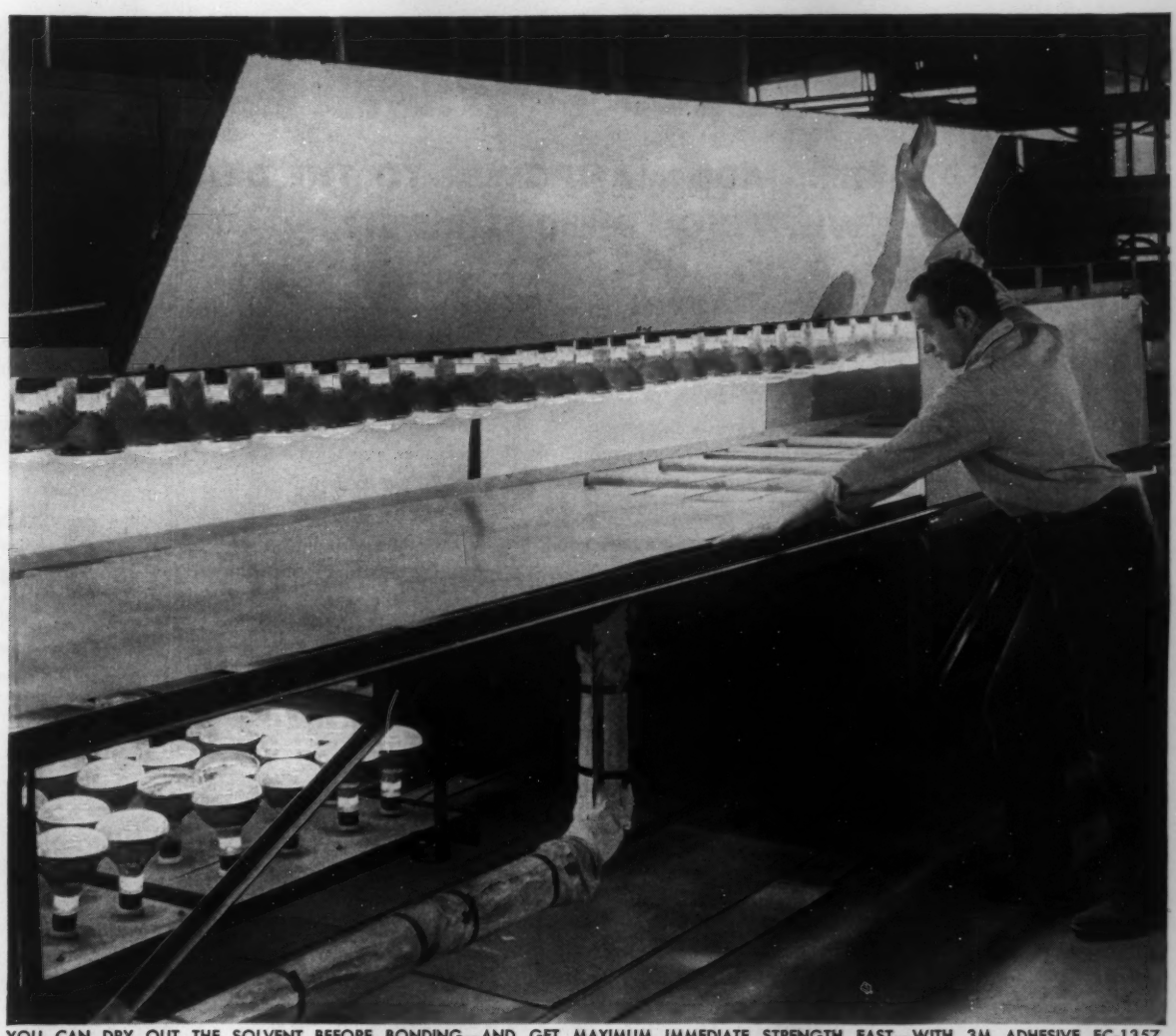
THE NATIONAL LOCK WASHER COMPANY

Serving Industry Since 1886

NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN

Circle 441 on page 19

Speed high-strength sandwich bonding by predrying 3M adhesive EC-1357



YOU CAN DRY OUT THE SOLVENT BEFORE BONDING—AND GET MAXIMUM IMMEDIATE STRENGTH FAST—WITH 3M ADHESIVE EC-1357.

Here's new speed in making light, rugged sandwich panels for non-load-bearing uses!

It's EC-1357. This specially formulated, fast adhesive from the laboratories of 3M gives you high bond strength *immediately!* With infrared ovens, you can dry the solvent out of EC-1357 before bonding. Heat absorption is fast, due to EC-1357's dark color. You eliminate unnecessary drying and storage time. You need no clamps or heated presses, just cold press or nip roller. What's more, this cold bond continues to cure at room temperatures—gains added strength with age.

On metal or paper honeycomb cores, EC-1357 builds up a fillet for bigger bonding area and strength. Use EC-1357 with glass foam cores, too.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU! Consult 3M Research, contact your 3M Field Engineer or write on your company letterhead for information and free literature to: 3M, Dept. 1010, 417 Piquette Ave., Detroit 2, Mich.

PRODUCT OF 3M COMPANY RESEARCH

MINNESOTA MINING AND MANUFACTURING COMPANY · ADHESIVES AND COATINGS DIVISION

417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 99 PARK AVE., N.Y. 16, N.Y. • CANADA: P.O. BOX 757, LONDON, ONT.

Circle 442 on page 19

"I proved it to myself... and you can, too...

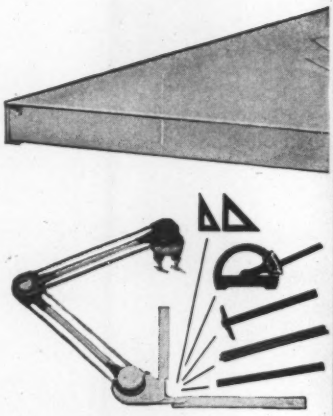
"BRUNING DRAFTERS DRAFTING JOBS BY 20

BRUNING DRAFTERS ADD MANPOWER TO THE DRAFTING ROOM — NOW WHEN YOU NEED IT MOST!

DRAFTSMEN! Prove it to yourself as have hundreds of skeptics who once frowned on using anything but conventional drafting tools like the T-square, triangle, and protractor. Bruning drafters actually speed drafting up to 40% on most jobs, up to 50% on some structural drawings . . . make your work far easier.

DEPARTMENT HEADS! The boom in production means pressure for more and more engineering drawings. With drafting space at a premium and experienced draftsmen hard to get, you couldn't find a faster or better way to add "manpower" than by boosting the output of your present draftsmen with modern, efficient Bruning drafters.

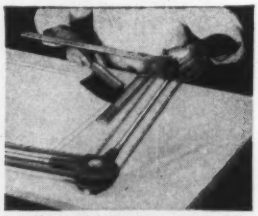
BRUNING DRAFTERS SPEED DRAFTING because they combine T-square, straightedge, triangle, protractor, and scales in *one* precision instrument. You eliminate the time and effort previously diverted to lifting, sliding, replacing, and reaching for these separate tools. Easily and quickly, you rotate, turn, and lift your Bruning drafter—all with the left hand. With fast fingertip control, you set and lock scales to any base line or angle. You accomplish everything that you can do with the conventional five basic instruments—only you do it much faster and much more accurately!



WHY BRUNING DRAFTERS ARE EASY TO OPERATE!

Bruning design permits complete 360 degree rotation about both the head and mast, making all parts of the board easily accessible—scales remain parallel to original angle setting. Patented Equipoise mechanism counteracts gravity on slopes up to 15°, literally "floats" your drafter into place without sag or "kickback." Exclusive Scalock device makes it easy to change scales, holds scales rigid while in use.

Automatic indexing stops at 15° intervals are engaged and released by just a press of the button on Bruning's unique Touch Control.

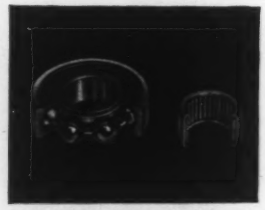


A ball-type joint between arms lets you lift your drafter over objects without unbalancing the machine or disturbing alignment of scales.

WHY BRUNING DRAFTERS ARE TOPS IN PRECISION AND DURABILITY!

Protractors have engine-divided graduations and double verniers reading to an accuracy of 5 minutes on most Standard models, to one minute on Civil Engineer models. A mathematically precise system of pulleys, machined to a tolerance of 0.0002", assures that drawing edges remain absolutely parallel to their original angle setting. Sturdy construction of the finest materials insures lasting accuracy and trouble-free operation.

Protractor and vernier graduations are set flush in the same plane to eliminate parallax error. Easy-to-read graduations are engine divided for accuracy.



Class #1 precision-ground, permanently lubricated ball bearings and frictionless needle bearings assure accuracy, effortless operation, and long life.

SPEED TO 40%!"

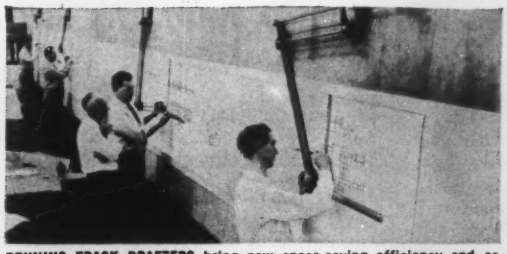
BRUNING

EQUIPOISE

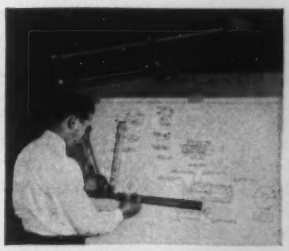
DRAFTING MACHINES

Exclusive Equipoise gravity compensator—finest on the market—permits use of drafter on inclined boards.

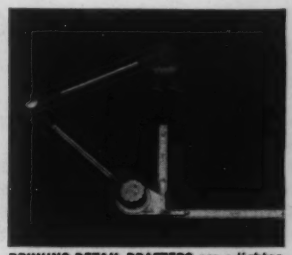
Standard protractor models—for mechanical, architectural, and structural draftsmen—are equipped with automatic indexing stops at 15° intervals. Civil Engineer protractor models—for civil, municipal, and utility engineers—have an azimuth scale, magnifier, and micrometer adjusting wheel. Arm lengths available to cover board areas from 36"x60" to 48"x96". Wide variety of scales. No extra charge for left handed models.



BRUNING TRACK DRAFTERS bring new space-saving efficiency and accuracy to firms that need extra-large drawings. Both single-arm and double-arm models offer automatic indexing, double verniers, and fast scale changes. Models are available to provide vertical coverage up to 84", unlimited horizontal coverage.



BRUNING COUNTERBALANCED DRAFTERS provide unusual speed, and accuracy in vertical drafting. Available with Standard or Civil Engineer head and same arm lengths as Equipoise drafters.



BRUNING DETAIL DRAFTERS are a lighter, more compact, and less expensive variation of larger Bruning machines. Ideal for smaller drawings and use in shops, schools, and in the field.

BRUNING

America's Leading Supplier of Engineering and Drafting Equipment

Offices in 37 Cities of the U.S. and Canada

CHARLES BRUNING COMPANY, INC.,
4700 MONTROSE AVENUE, CHICAGO 41, ILLINOIS

In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

Charles Bruning Company, Inc., Dept. 104-K
4700 Montrose Ave., Chicago 41, Illinois

Please send me the free, 20-page booklet on Bruning drafting machines.

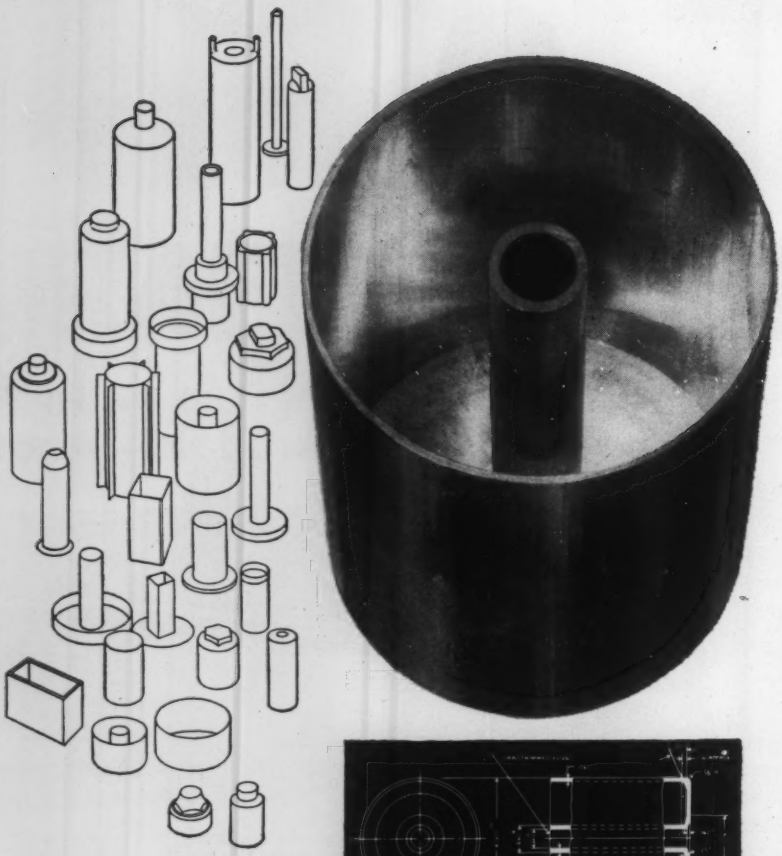
Name_____ Title_____

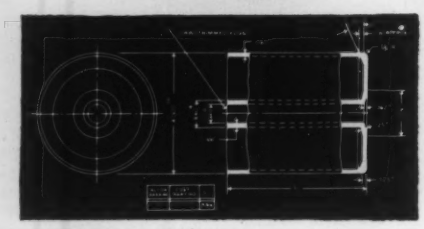
Company_____

Address_____

City_____ County_____ State_____

Circle 443 on page 19





made in one piece–in one stroke as an **ALCOA IMPACT**

Faced with the problem of designing this center-tube impact as a one-piece part, a designer who is not familiar with Alcoa® Impacts would throw up his hands. Then he would break out the slide rule to start figuring costs on welding the center tube to the base. After that, he'd have to puzzle out an inexpensive way to join the base to the side wall. The fact is, he never would figure out a way to do it economically.

To the informed designer who *is* familiar with Alcoa Impacts, this would be just another routine job that he could rely on Alcoa's Impacts experts to knock out for him. In spite of its rather complicated design, it is formed (as are all impacts) in a fraction of a second, with a single stroke of the punch. It is a strong, lightweight, seamless part. Actually made better, stronger and more economically than it could have been by *any* other fabricating method.

To guide your thinking, check the handy rules of thumb below. Any part that is a closed-end tubular part, or cup-shaped, should be considered as an Alcoa Impact. In one shot, we can make round, oval, square or special shapes. Ribs, splines, flutes or other functional or decorative patterns can be incorporated on the inside or outside. Let your imagination go to work; we're anxious to go to work for you.

To get your imagination started, send for Alcoa's design manual, *Alcoa Impacts—Metal in Motion*. You'll find it loaded with design tips and ideas that have saved other designers a lot of money. For on-the-spot assistance, call your nearest Alcoa sales office. It's listed under "Aluminum" in the Yellow Pages of your telephone directory. An Alcoa sales engineer will put his solid technical know-how at your disposal. Aluminum Company of America, 1991-K Alcoa Building, Pittsburgh 19, Pa.

Some Impact Rules of Thumb—Check your problems against this list:

1. Parts requiring hollow sections—either tube or cup-shaped with one end closed.
2. Parts with walls or surfaces requiring zero draft.
3. Parts requiring lengths up to eight or ten times the diameter.
4. Parts requiring the strength of forgings.
5. Parts requiring tolerances down to $\pm 0.005''$.
6. Parts requiring ribs, bosses or fins as integral parts.
7. Parts requiring low unit cost in mass production. (Often the savings in machining, fabrication and assembly made by impacts amortize tooling in relatively short runs.)

ALCOA ALUMINUM IMPACTS

YOUR GUIDE TO THE BEST IN ALUMINUM VALUE

NEW!
"ALCOA THEATRE"
Exciting Adventure
ALTERNATE MONDAY EVENINGS

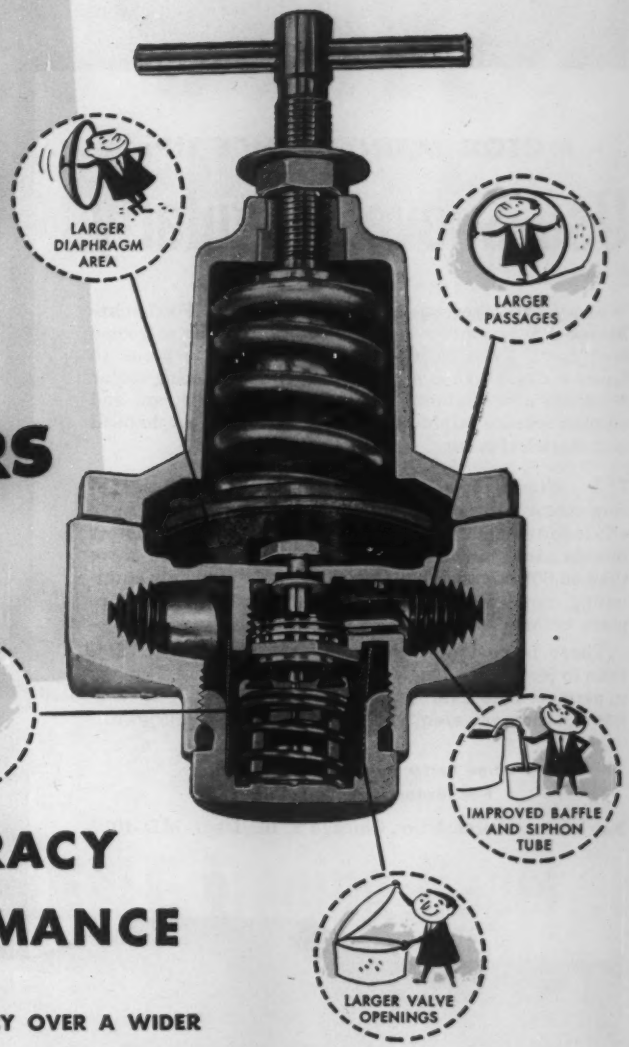
Circle 444 on page 19

NEW...

Norgren

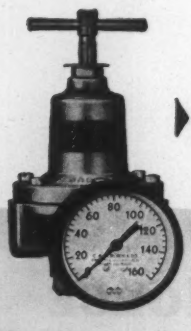
PRESSURE REGULATORS

FOR AIR, WATER, OIL,
NON-CORROSIVE LIQUIDS
AND GASES



GREATER ACCURACY
BETTER PERFORMANCE

- **IMPROVED ACCURACY OVER A WIDER OPERATING RANGE**
- **GREATER ACCURACY OF REGULATED PRESSURE** even with widely fluctuating line pressure and rapidly varying flow.
- **LARGER FLOW CAPACITY**
  - a. Balanced Valve Construction
  - b. Greater Effective Diaphragm Area
  - c. Improved Baffle and Siphon Performance
  - d. Larger Passages
  - e. Larger Valve Openings
- **RELIEVING AND NON-RELIEVING TYPES AVAILABLE FOR AIR**



For complete information on all your regulator needs, ⅛" to 2" inclusive, call your nearby Norgren Representative listed in your telephone directory — or WRITE FACTORY FOR LITERATURE.

C. A. NORGREN CO.

3442 SO. ELATI STREET • • • ENGLEWOOD, COLORADO

Circle 445 on page 19

MOTOR MAINTENANCE TIP:

Use Shovel Regularly

Without the vigorous use of a shovel, this Fairbanks-Morse 100 hp. motor would be buried under corrosive coal dust. Even so, as it drives a briquette press 16 hours a day, there is a cloud of coal dust coating motor windings and inhibiting normal cooling . . . steam and sulphur release sulphuric acid that can cause mechanical and electrical failure.

YET—After eight years in this rugged service the slip-ring motor in its dripproof frame has operated at peak efficiency without a single breakdown. Other F-M motors in this same difficult environment have operated more than 40,000 hours without breakdown—completely eliminating motor failures where such failure was commonplace before.

There is no better way to judge design advantages than to look at the long performance record of equipment in service. Your nearby Fairbanks-Morse Motor Specialists can show you many applications similar to your own.

When Performance Is the Measure,
F-M Motors Are the Standard.

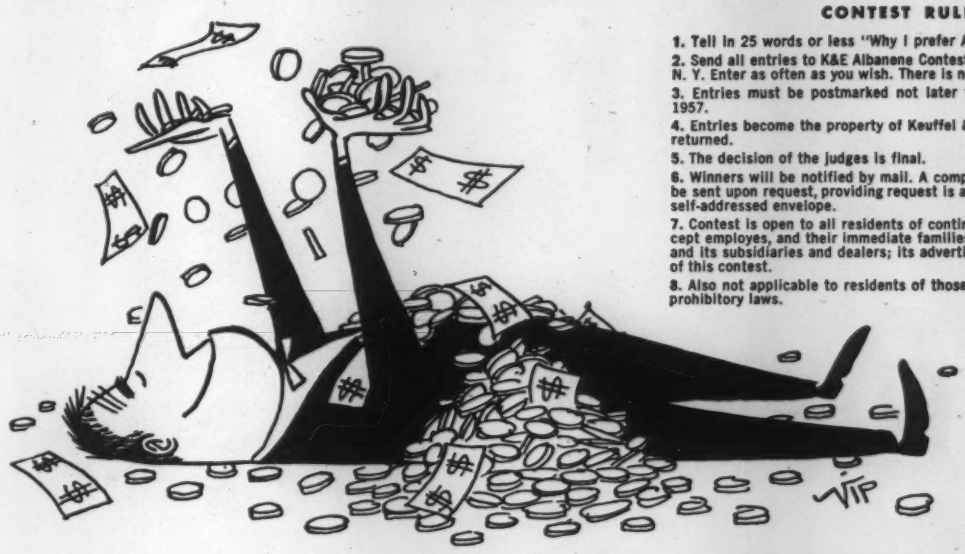
Fairbanks, Morse & Co., Chicago 5, Ill., Dept. MD-1017.

FAIRBANKS-MORSE

a name worth remembering when you want the BEST

ELECTRIC MOTORS AND GENERATORS • DIESEL LOCOMOTIVES AND ENGINES • PUMPS • SCALES • RAIL CARS • HOME WATER SERVICE EQUIPMENT • MAGNETOS

ENTER THIS CONTEST ...90 CASH PRIZES!



CONTEST RULES

1. Tell in 25 words or less "Why I prefer Albanene tracing paper."
2. Send all entries to K&E Albanene Contest, Box 160, New York 46, N. Y. Enter as often as you wish. There is nothing to buy.
3. Entries must be postmarked not later than midnight, Nov. 30, 1957.
4. Entries become the property of Keuffel & Esser Co. None can be returned.
5. The decision of the judges is final.
6. Winners will be notified by mail. A complete list of winners will be sent upon request, providing request is accompanied by stamped, self-addressed envelope.
7. Contest is open to all residents of continental United States, except employes, and their immediate families, of Keuffel & Esser Co. and its subsidiaries and dealers; its advertising agency; and judges of this contest.
8. Also not applicable to residents of those states where there are prohibitory laws.

Why I prefer ALBANENE® Tracing Paper...

First prize $1500
Second prize $1000
Third prize . . . . . $ 500

plus 87 prizes of $25 each!

In 25 words or less, tell us why you prefer K&E Albanene® tracing paper. Your reasons may win one of these 90 prizes (it's K&E's 90th anniversary).

Here's a hint: Albanene is made from 100% rag stock for superlative tear strength. It is permanently transparentized with an inert resin. Draftsmen like it because of its easy drawing qualities... reproduction men for its high transparency and permanence. Everybody likes it because "what you pay for stays in the paper." That's why Albanene is the best seller among *all* tracing papers.

Get contest aids from your K&E dealer: Information booklets, extra contest entry blanks, samples of Albanene, too, if you need them. You can enter as often as you please.

Or use a plain sheet of paper if someone's already snipped the blank below. Give your name, address, and firm name, twenty-five words or less telling why you prefer Albanene tracing paper, and mail to K&E Albanene Contest, Box 160, New York 46, N. Y. before midnight, November 30, 1957.

KEUFFEL & ESSER CO.
New York, Hoboken, N. J., Detroit, Montreal, Chicago, St. Louis, Dallas, San Francisco, Los Angeles, Seattle.
Dealers in principal cities

K & E Albanene Contest, Box 160, New York 46, N. Y.

Here's why I prefer Albanene Tracing Papers_____

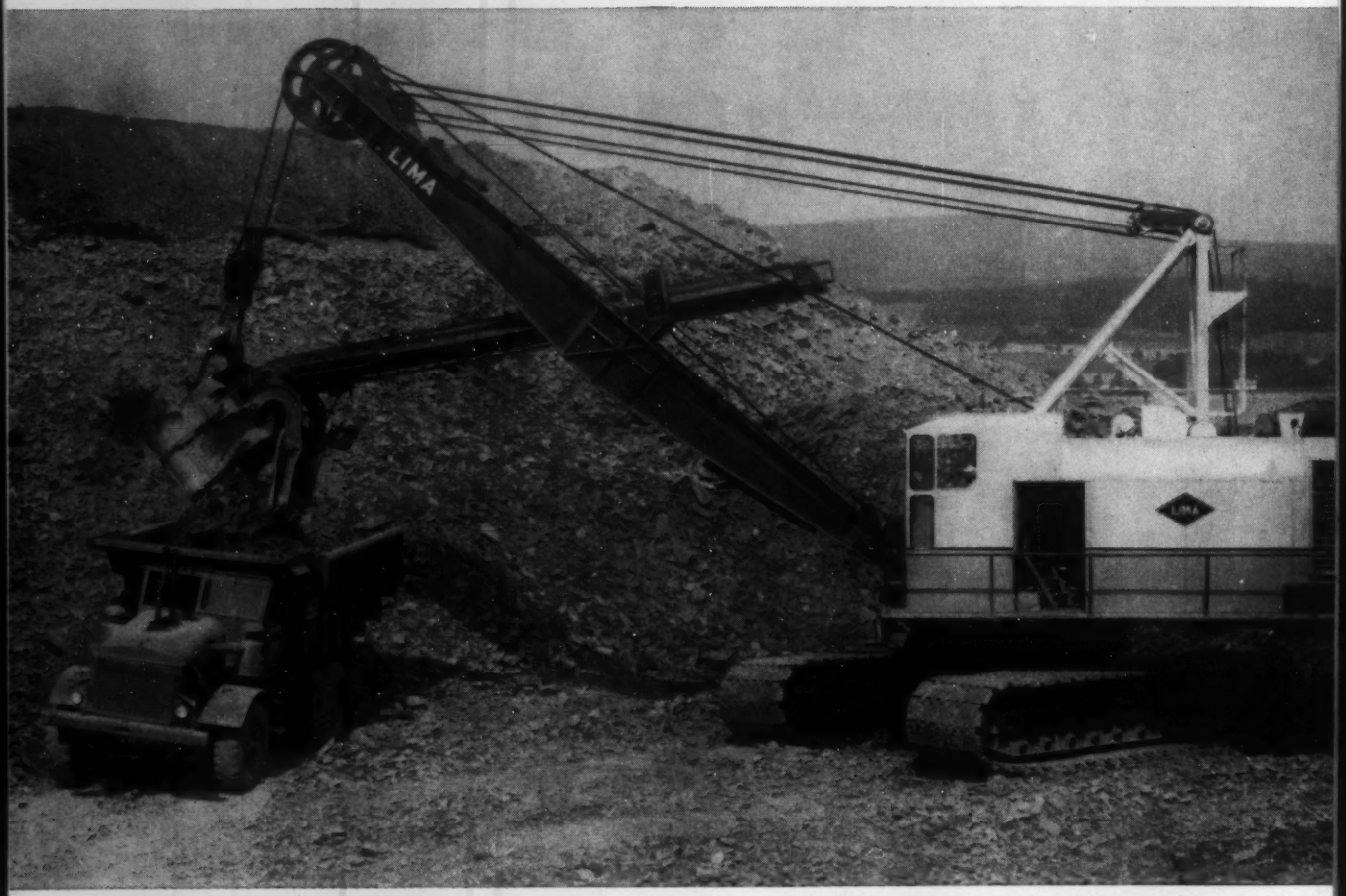
_____

_____

*Name*_____ *City*_____ *Zone*_____ *State*_____

*Street*_____ *Firm Name*_____

Specifically developed for equipment



To obtain the strongest possible dipper handle

The dipper stick of this 6-cu.-yd. Lima power shovel is made of USS TRI-TEN Steel, hot-pierced and drawn into a tube, with 18" O.D. and 1½"-thick wall. Says the manufacturer, "We adopted USS TRI-TEN Steel to obtain the strongest possible dipper handle with the minimum of weight. A dipper handle is subjected to bending strain, as well as heavy impact loading, yet weight must be kept as low as possible since excess weight means the reduction of payload. Previously used ordinary steels did not stand up to hard usage."

20 cubic yards at a bite

This big-capacity Bucyrus Erie dragline bucket can scoop up 20 cu. yds. of overburden at one bite. It has to stand pounding far beyond the ordinary. That is why it was built with USS TRI-TEN Steel which ensures rugged strength and high resistance to impact and shock at any atmospheric temperature. The good welding and working properties of USS TRI-TEN Steel, even in the heavy thicknesses required here, greatly facilitate fabrication.

UNITED STATES STEEL
USS
HIGH STRENGTH STEELS
1933 1957
24 YEARS OF PERFORMANCE

that has to take it on the chin...

USS TRI-TEN High Strength Steel

THE PUNISHING ABUSE that today's heavy-duty earth moving and mining equipment has to withstand puts a high premium on durability.

Unless power shovels, draglines, trucks, bulldozers, scrapers and mechanized mining units have the rugged stamina to stay on the job under all conditions, day after day, the many thousands of dollars invested in them can easily become a losing proposition. Breakdowns, repairs and maintenance must be kept to a minimum. That's why USS TRI-TEN High-Strength Low-Alloy Steel is being increasingly used in the vital parts of such equipment.

USS TRI-TEN Steel has special properties that recommend it for applications where maximum ruggedness, toughness, strength and endurance—*combined with minimum weight*—are of prime importance.

An outstanding advantage of this steel, and one that will be appreciated by every equipment user who has been plagued by part breakage during severe cold spells, is USS TRI-TEN Steel's ability to withstand impact shock at sub-zero temperatures.

Not only is USS TRI-TEN Steel very tough but it is very strong as well. Its yield point of 50,000 psi min.* is 1½ times that of structural carbon steel and is combined with a tensile strength of 70,000 psi min. in thicknesses of ¾" and under, with moderately lower values as thicknesses increase up to 4". TRI-TEN Steel, too, has greater resistance to abrasion than structural carbon steel. It has twice the resistance to atmospheric corrosion. Its fatigue resistance is 50% higher. And its cost is low.

In addition, USS TRI-TEN Steel has good weldability and excellent workability, important factors that help to cut costs in fabrication and repair work. Our 174-page "Design Manual for High Strength Steels" will guide you in applying USS TRI-TEN Steel most efficiently and economically. Write for your free copy—on your company letterhead, giving your title or department—to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

**Still higher strength can be obtained with USS "T-1" Steel—a constructional alloy steel that offers a yield strength of 90,000 psi min. and tensile strength of 105,000 psi min. combined with weldability and tremendous toughness.*

To absorb the grief of heavy duty

Used in the Minnesota iron ore mines, the entire interior surface of this 24-cu.-yd. Heil dump truck body is of USS TRI-TEN Steel. The floor is 1"-thick plate, sides and front are ⅜" plate. Experience on the Iron Range has proved that TRI-TEN Steel provides the strength and toughness necessary to withstand severe impact and loading shocks even in the coldest weather. And it does this better and more economically than many more expensive grades.

United States Steel Corporation, Pittsburgh · American Steel & Wire Division, Cleveland · Columbia-Geneva Steel Division, San Francisco
National Tube Division, Pittsburgh · Tennessee Coal & Iron Division, Fairfield, Ala. · United States Steel Supply Division, Warehouse Distributors
United States Steel Export Company, New York

USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

"USS," MAN-TEN, COR-TEN, TRI-TEN and "T-1" are registered trademarks of United States Steel

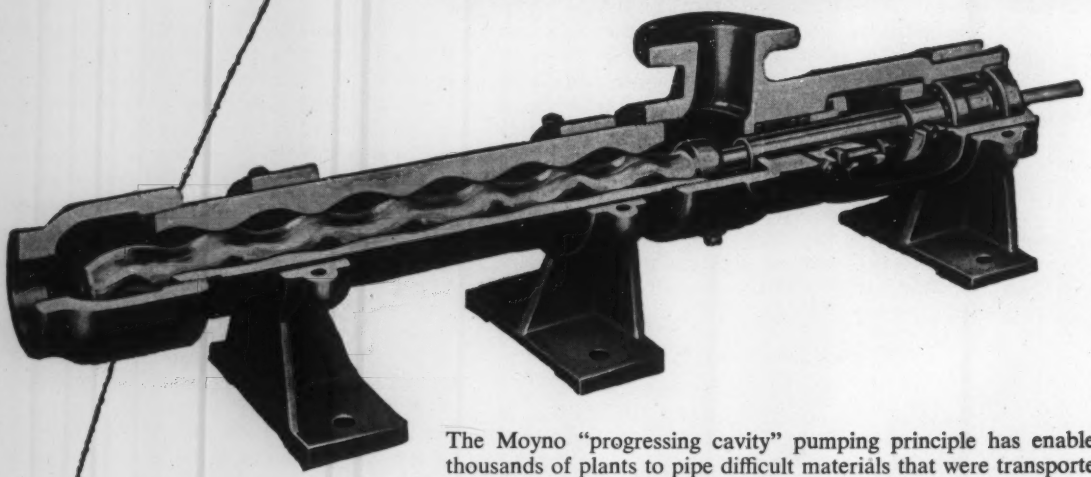
Circle 448 on page 19

UNITED STATES STEEL

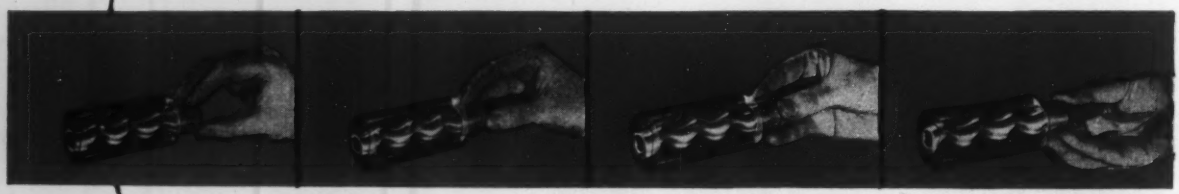
from abrasive slurries to delicate foods . . .

MOYNO® PUMPS

CUT HANDLING COSTS



The Moyno "progressing cavity" pumping principle has enabled thousands of plants to pipe difficult materials that were transported by hand and other expensive means. Moyno is the only pump that can handle many abrasives, pastes, slurries, chemicals, foods, suspended solids, etc., without foaming, aerating, crushing or excessive pump wear.



As shown above, Moyno Pumps have a screw-like rotor that revolves in a double threaded stator creating progressing cavities which smoothly move material through the pump. They will pump anything that will move through a pipe . . . even plaster and non-pourable pastes!

Moyno Pumps are available in capacities up to 500 gpm and pressures up to 1000 psi.

Examine your processing methods. No doubt there are several places where Moyno Pumps can drastically cut costs. Ask us, we'll give you a frank answer. Send us an outline of your problem today! Write for Bulletin 30-MD

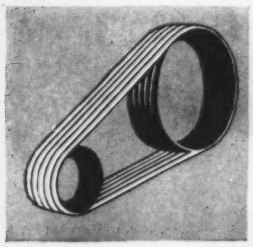
R&M®

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO — BRANTFORD, ONTARIO

Motors · Fans · Hoists · Moyno® Pumps · Propellair® (Industrial) Fans

Circle 449 on page 19

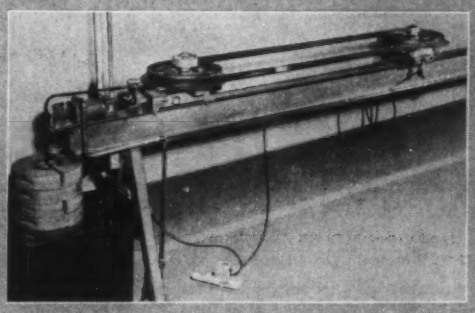


for driving reliability...

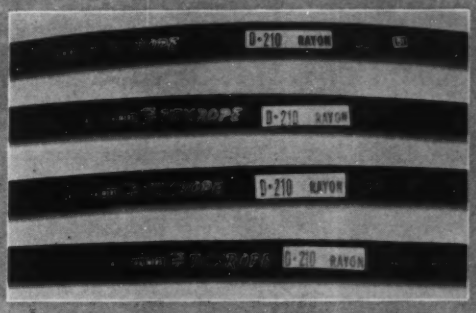
New **4-STEP** matching program gives

TEXROPE BELTS

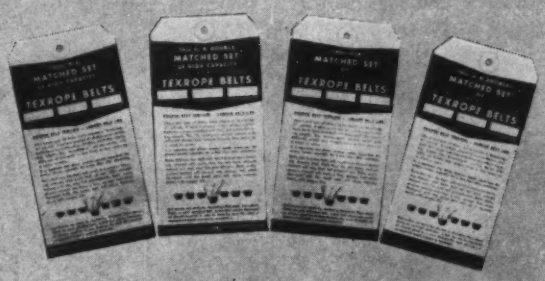
even greater efficiency



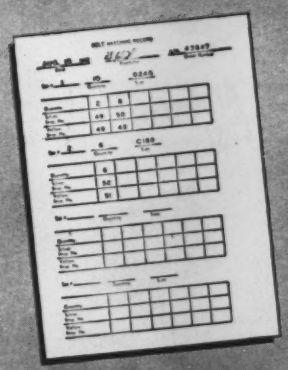
Step 1 — Immediately after manufacture, every Texrope belt is accurately measured on modern equipment and its length is coded on the belt.



Step 2 — Belts are then grouped in matched sets at the factory. These belts must adhere to minute length limitations.



Step 3 — Distinctively colored tags are used to mark each matched set, thus assuring you true performance on multiple V-belt drives.



Step 4 — A factory record is kept of the belts furnished in each set. This permanent registration is the user's "insurance policy" against mismatching. AND, if prolonged factory stocking should occur, each set is re-matched to provide a double-check on adherence to requirements.

This new program pays off in peak drive efficiency for your equipment. Find out more from your A-C district office or distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5402

Circle 450 on page 19

why shell castings from CENTRAL FOUNDRY DIVISION offer new design possibilities and reduced costs per part

In the shell-casting process phenolic resin is combined with sand for the mold material. This basic difference brings about a great many advantages . . .

Shell-cast castings give excellent duplication of detail since the curing of the shell on the pattern produces a hard, smooth mold which is as accurate as the pattern itself. Thus, shell molds permit deep pockets and recesses to be drawn, making possible complex designs impractical by any other method.

Central Foundry Division has been casting by the shell process since 1951. During that time, techniques have been brought to a high degree of perfection and control.

The absence of surface-sand on shell castings increases machine-tool life tremendously. At the same time, shell cast parts, being cleaner to start with, reduce or eliminate the need for additional cleaning by the customer.

The reduced machining and waste, elimination of costly cores, better surface detail, increased tool life and savings in machine scrap, combine to open countless new opportunities for you in both design and cost savings.

Perhaps shell castings can help you make your product still better and at a savings in cost. Shell castings are available in grey iron, alloy grey iron, malleable iron or ArmaSteel®. Write us today for your copies of the free, factual books, ARMASTEEL and SHELL CASTINGS. Or, tell us about your casting problems. Our research and engineering staff is ready to employ spectroanalysis, stress analysis, sonic testing, and other improved foundry methods in helping you seek a solution.

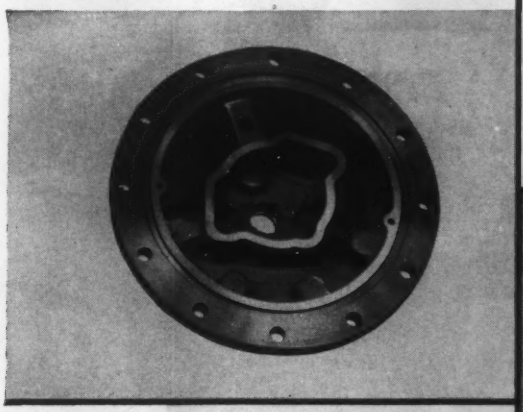
CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

Typical shell mold showing cope and drag

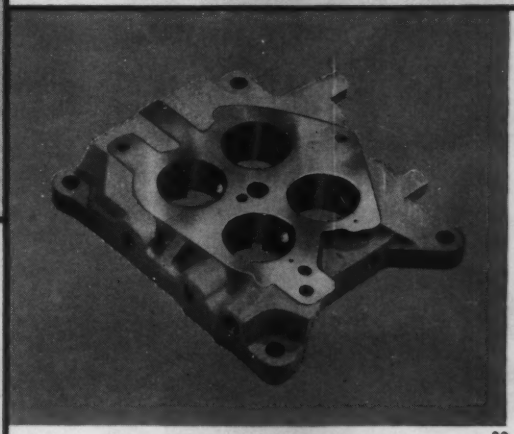
Shell molding permitted the casting of intricate grooves and recesses in this governor body which would be too costly by any other method

Machining of the O.D. was eliminated by shell casting this refrigeration compressor head



Better dimensional control by the shell process simplifies the balancing of crankshafts

Uniformity of shell castings makes automotive rocker arms more adaptable to automatic machining



Closer tolerances of shell castings often eliminate machining on clearance and non-functional surfaces

UNIONMELT Welding
makes rugged seams for rugged machines

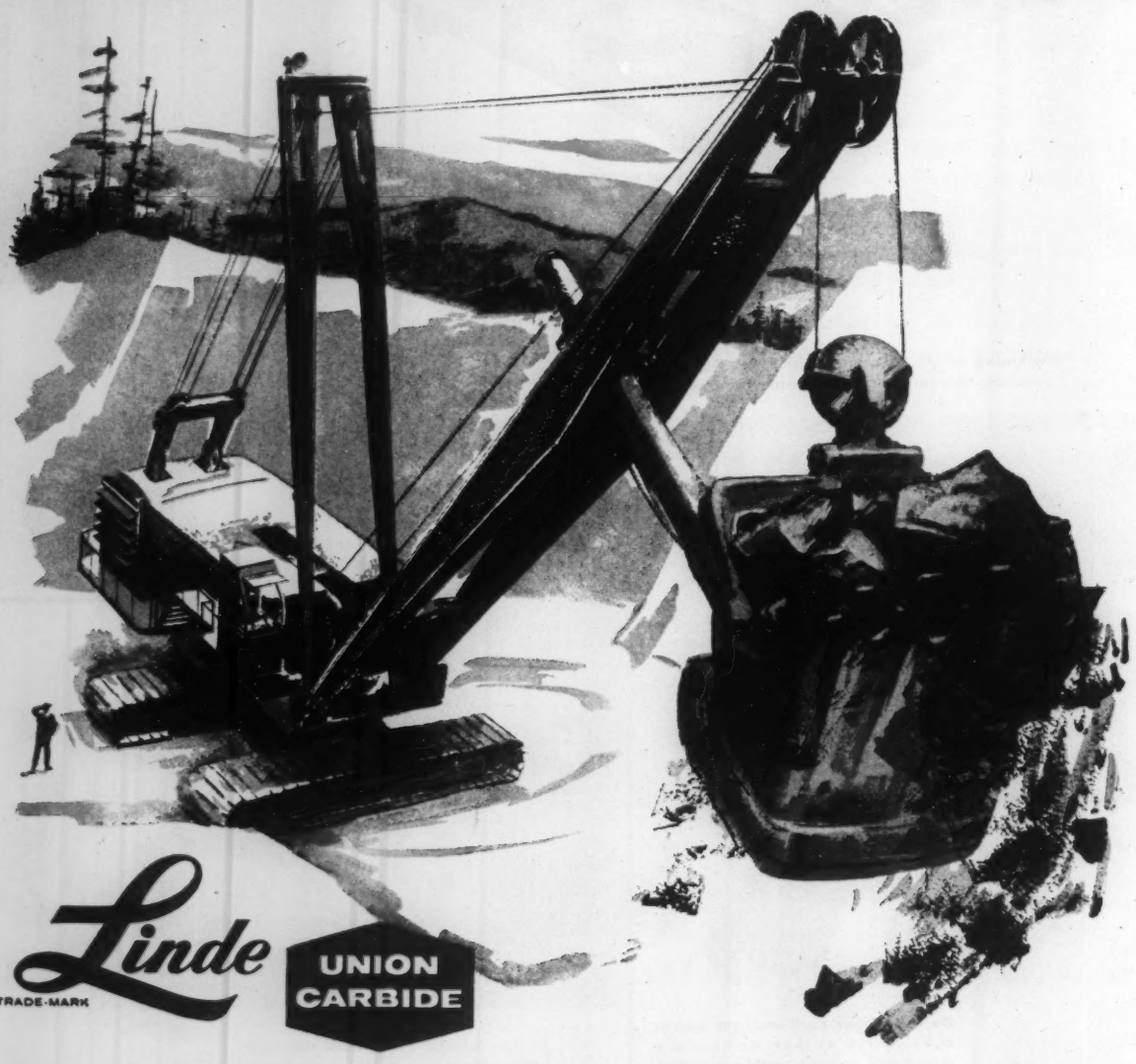
Tough and heavy road-building machines are no stronger than the welds that hold their working parts together. Making sound joints in thick steel is a job made to order for LINDE's UNIONMELT Submerged Melt Electric Welding.

Using UNIONMELT Welding, you get dense, deep welds in metal up to 1½ inches thick in a single pass. There's no limit to thicknesses you can join with multiple passes. Welds are uniformly clean and smooth. With the right combination of UNIONMELT Composition and welding rod, alloy steels and even non-ferrous alloys can be welded as easily as steel—manually or automatically.

Get all the facts about UNIONMELT Welding, and LINDE's other modern welding methods. For a free copy of the booklet, "Modern Methods of Joining Metals," address Dept. MD-10. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada*: Linde Company, Division of Union Carbide Canada Limited.

LINDE's UNIONMELT Welding gives dense, sound welds in light-gage or heavy metals, at high speeds, automatically or manually.

FOR THE BEST IN ELECTRIC WELDING—LOOK TO LINDE!



Linde
TRADE-MARK

UNION CARBIDE

The terms "Linde," "Unionmelt," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

WHICH of these Actuation Problems are YOURS?

- ☐ POWER CONSUMPTION
- ☐ SPACE/WEIGHT
- ☐ PRECISION
- ☐ TEMPERATURE
- ☐ LUBRICATION
- ☐ DEPENDABILITY

SAGINAW b/b SCREWS will help you solve them!

If one circuit should fail, the rest will function without interruption, sharing the load between them. In critical applications this feature has no equal.

6 BASIC DESIGN ADVANTAGES

1. Vital Power Savings. Permit much smaller motors with far less drain on electrical system, simpler circuitry.

2. Space/Weight Savings. Screws themselves are smaller, lighter; permit smaller motors and gear boxes; eliminate auxiliary equipment required by hydraulics.

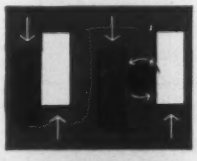
3. Precise Positioning. Machine-ground type will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0006 in./ft. of travel.

4. Temperature Tolerance. Normal operating range from −75° to +275° F.; in selected materials, will function efficiently at temperatures as high as +900° F.

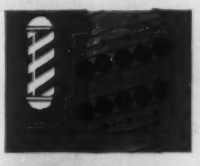
5. Lubrication Latitude. If lube fails, will still function with remarkable efficiency. Units have been built and qualified for operation without lubrication.

6. Fail-Safe Performance. Far less vulnerable than hydraulics; Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance against failure.

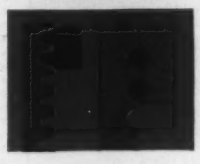
Here's why they're 90% efficient, save 4/5 on torque:



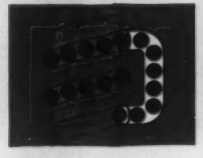
Let's start at the beginning, with the familiar principle that there's far less friction in *rolling* than in *sliding*. By applying this principle,



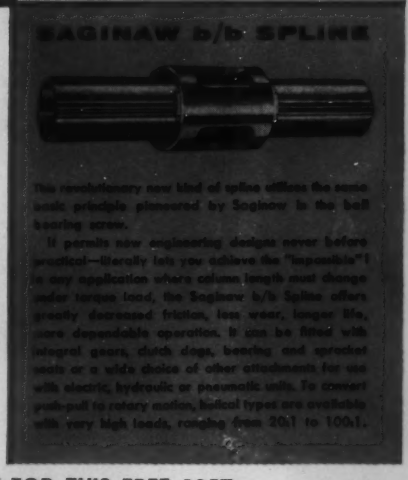
Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



the *Saginaw ball/bearing Screw* radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of *sliding*, mating surfaces *glide* on rolling steel balls.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.



This revolutionary new kind of spline utilizes the same basic principle pioneered by Saginaw in the ball bearing screw.

It permits new engineering designs never before practical—literally lets you achieve the "impossible"! In any application where column length must change under torque load, the Saginaw b/b Spline offers greatly decreased friction, less wear, longer life, more dependable operation. It can be fitted with integral gears, clutch dogs, bearing and sprocket seats or a wide choice of other attachments for use with electric, hydraulic or pneumatic units. To convert push-pull to rotary motion, helical types are available with very high loads, ranging from 20:1 to 100:1.

Available in custom machine-ground and stock rolled-thread types. Units have been built from 1½ inches to 39½ feet long—⅜ to 10 inches in diameter.

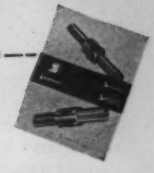
Outstanding opportunities for qualified engineers

Saginaw b/b ball bearing Screws and Splines

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • SAGINAW, MICHIGAN
WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

SEND TODAY FOR THIS FREE 1957 ENGINEERING DATA BOOK . . .

or see our section in Sweet's Product Design File



Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 9H, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME_____

COMPANY_____ TITLE_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

Circle 453 on page 19

FAST, HAMMER-DRIVEN RIVET ECONOMICAL FOR BLIND AND OPEN APPLICATIONS

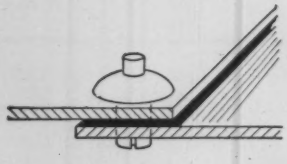


Fig. 1 Inserted in hole, Southco Rivets are quickly set by driving pin with hammer. No special tools are required. Bucking is not necessary.

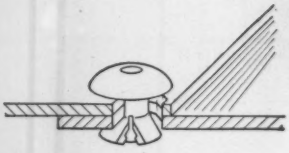


Fig. 2 Expanded prongs force sheets or parts together, hold them tightly in compression. No metal is removed, no grinding or finishing is required.

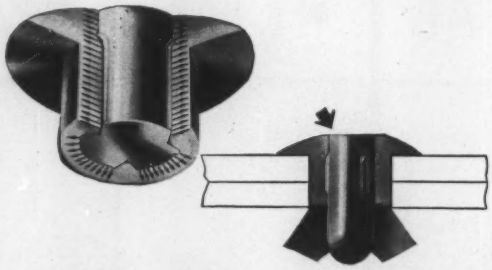


Fig. 3 Pin is locked securely into rivet by displaced metal filling unique grooves. Compression forces are utilized for greater strength.

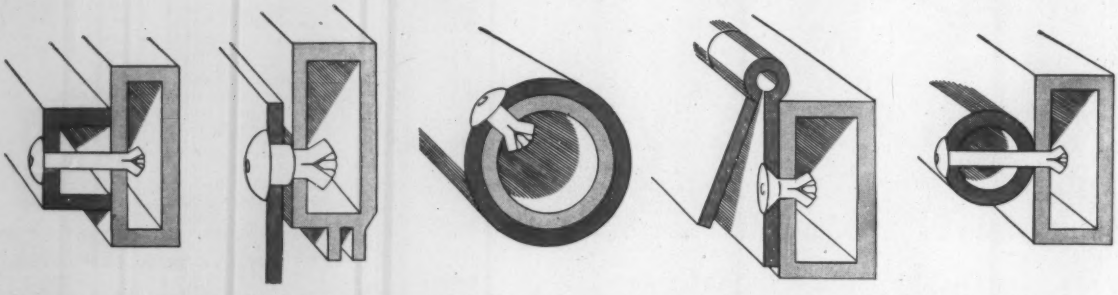


Fig. 4 Ideally suited for "blind" applications, Southco Rivets are worked by one man from one side only and require minimum space inside closed area. They eliminate costly bucking arrangement or time-consuming finishing. Supplied as a unit, they require no job time for assembly or fitting.

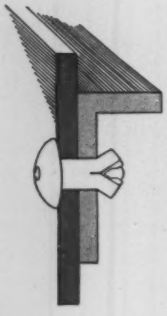


Fig. 5 Access or open fastening utilizes the simplicity, speed and vibration-resistance of Southco Rivets.

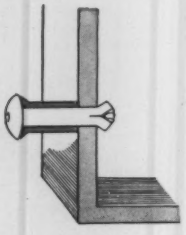


Fig. 6 Ferrules are used as spacers for numerous applications. Here the Southco Rivet forms a drawer pull in conjunction with a flanged tube.

Fig. 7 Increased head size distributes holding pressure over larger area, permits higher loading on wood, plastics and similar materials.

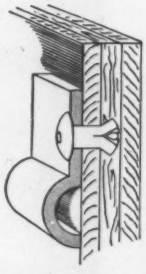
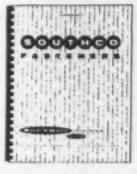


Fig. 8 A blind head can be formed inside the wood. This application is particularly useful when it is desirable to have one surface of the wood unmarred.

FREE!
Fastener Handbook



Send for your free copy of Handbook No. 7. Complete data for designers on these and many other specialty fasteners. 52 pp., two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pennsylvania.

SOUTHCO FASTENERS
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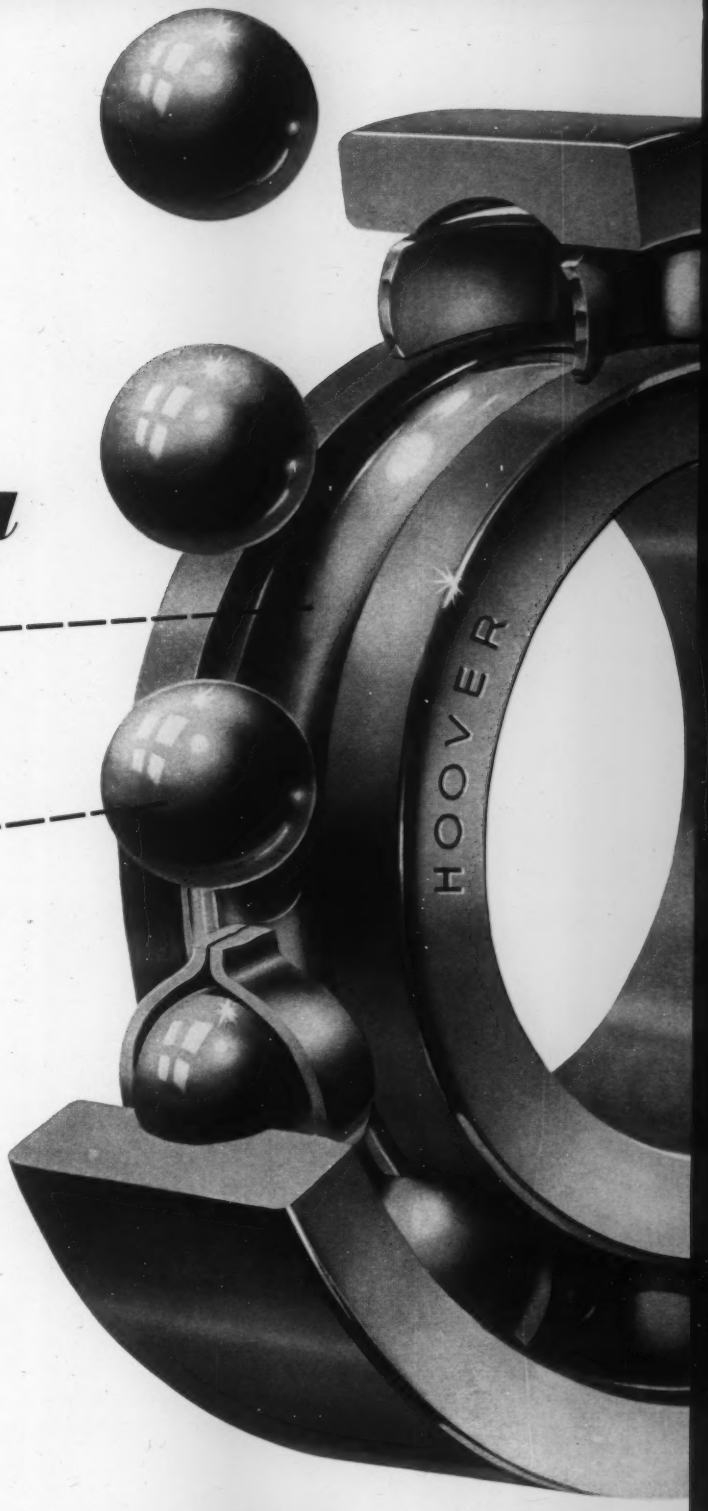
LION

Circle 454 on page 19

Circle 455 on page 19→

only hoover gives you



Hoover Honed Raceways

which are not only ground, but also fully honed with a unique process developed and used only by Hoover. The result: super smooth, superbly finished raceways of microscopic accuracy and perfection.

Micro-Velvet Balls

made of the finest of selected high carbon chrome alloy steel, uniformly hardened throughout, then surface finished so perfectly that roundness and diameter are accurate within *millionths* of an inch! The gleaming surfaces are absolutely free of even the tiniest of defects.

Perfectly Matched

ball complements are fitted into perfectly matched raceways . . . a final quality step that pays off in maximum load capacity, hushed quietness and extra long life for which Hoover Ball Bearings are so well known. Bearing types available: single row, single and double shield, combination felt seal and shield, double row, cartridge, single and double contact seal.

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ANN ARBOR, MICHIGAN
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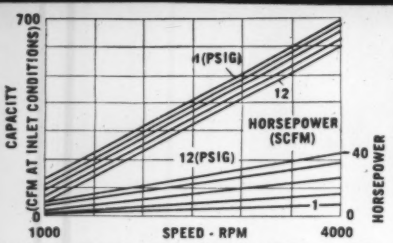
WRITE FOR YOUR COPY OF THE HOOVER HANDI-BOOK OF ANTI-FRICTION BEARINGS.
Keep accurate, concise information at your fingertips to help you select proper bearings and solve bearing problems.

Significant Advantages... Every Way You Compare Them!

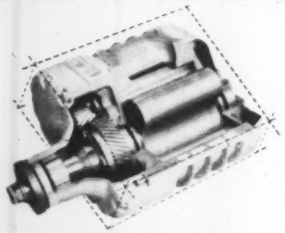
MIEHLE-DEXTER 3-LOBE ROTARY POSITIVE BLOWERS OFFER WIDER PRESSURE AND SPEED RANGE, LESS CUBE, LIGHTER WEIGHT

Pressure Range From 1 to 12 psig; Speed Range From 1000 to 4000 rpm



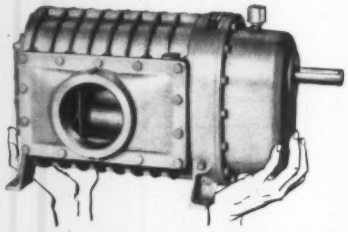
M-D Blowers operate at wider pressure and speed ranges than other rotary positive blowers. The capacity of a typical M-D Blower (Model 4012 with a 4" rotor 12" long) at various pressures and speeds is shown at the left. The capacities of eleven other production models range from 50 to 4000 cfm.

Smallest Cube Dimension of All Rotary Positive Blowers



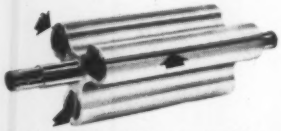
Less space is required for M-D Blowers than any other rotary positive blower because of the exclusive 3-lobe rotor design. This means M-D Blowers can be integrated into existing systems without requiring major space reallocations. The space-saving advantage of M-D Blowers for original installations is obvious.

Lightest Weight With Aluminum Rotors and Housing



M-D Blowers weigh considerably less because of aluminum rotors and housings, standard for most models. This construction not only simplifies installation but provides greater structural strength. The 3-lobe rotor design provides the capacity you require in smaller space with lighter weight.

Exclusive Formica Wear Strips On Rotors; Rubber Grid On End Plate



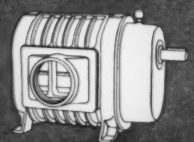
Exclusive formica wear strips on each rotor lobe reduce clearance between rotor lobes and housing to practically zero.

The patented synthetic rubber grid, vulcanized to the metal end plate by a special process, eliminates metal-to-metal contact between the rotor and the end plate — assures longer rotor life and efficient operation.

➡ The performance figures are convincing . . . WRITE TODAY!

Miehle Dexter

3-LOBE



ROTARY POSITIVE BLOWERS

Important advantages in pressure range, size, weight, cost, service!

MIEHLE-DEXTER DIVISION, RACINE, WIS. • TELEPHONE MELROSE 4-5521 • Another Product of MIEHLE-GOSS-DEXTER, Incorporated

DESIGN for Lower Cost

In many instances, designing for production on a Fellows Gear Shaper offers exceptional opportunities to lower costs, on non-involute shapes as well as gears. This is particularly true where gear shaper versatility makes it possible to generate multiple parts on the same shaft, thus eliminating assembly operations and simplifying design.

The unusual multiple cam and gear part shown is an example. The gear and various cams are positioned to within 0.001" alignment. Since there were no keyways or other machining required for assembly, there was a considerable reduction in production time, in addition to the time saved because of the high cutting speed of the gear shaper. Finally, the integral design resulted in a saving in weight without loss of strength.

These and other advantages of the method are described and illustrated in the booklet, "The Art of Generating with a Reciprocating Tool." This booklet, although not new, contains a lot of information that is valuable to designers concerned with generated shapes. Since 1951 we have distributed over 10,000 copies. If you would like one, just write us.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices: 1048 North Woodward Ave., Royal Oak, Michigan
150 West Pleasant Ave., Maywood, N. J.
5835 West North Ave., Chicago 39
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THE PRECISION LINE

Fellows *Gear Production Equipment*

Circle 457 on page 19

On this automatic buffing machine

ASK FOR YOUR NEW G-E THYMOTROL SELECTOR GUIDE TODAY

To help you in selecting a general-purpose Thymotrol drive, General Electric has prepared a new selector guide. This easy-to-use selector puts basic data on ratings, frame sizes, dimensions, and model numbers right at your finger tips.

For your selector guide—covering both fractional and integral drives up to 3 HP—call your nearest G-E Apparatus Sales engineer today.

a General Electric Thymotrol* drive upped production 35%, cut rejects 25% and actually cost up to $173† less!

At Chase Brass & Copper Company, a General Electric Thymotrol drive—costing up to $173 *less* than other suitable adjustable-speed drives—is controlling the final operations of an automatic buffing machine.

Chase formerly used a mechanical drive system to change set-up for various parts. With hand adjustment, resetting the time cycles and speeds of the buffing wheel required a minimum of one hour's work. Even then product uniformity was not assured.

With its new G-E Thymotrol drive, Chase has increased production 35%, is getting a more uniform product, and has drastically cut rejects. Specifically Chase has found that G-E Thymotrol drives give:

- **Closer speed tolerances** than with the previously used mechanical drive systems.
- **Fewer rejects** and greater uniformity of product due to the precise speed control of the G-E Thymotrol drive.
- **Increased production** since the time-consuming—and less precise—job of resetting the mechanical drive is eliminated. Now all that's required is the simple adjustment of a dial.

*Reg. Trade-mark of General Electric Company.

- **Preset speed control** which reduces the possibility of human error, since the G-E Thymotrol drive is preset to operate at optimum speed for each job.

Mr. John Hornbecker, superintendent of maintenance for Chase Brass & Copper Company, says, "By pre-setting the Thymotrol drive, we get a uniform high-quality product at all times. Our tool setter merely sets the control for the speed best suited for each job, and the constant speed of the wheel maintained by the G-E Thymotrol drive delivers a uniform product."

ONE OF MANY APPLICATIONS

This is just one of a wide range of G-E Thymotrol drive applications. Today, these drives are being applied to virtually all types of machines whose performance is improved with adjustable speed.

Select G-E Thymotrol drives and get the perfect combination—*outstanding performance at low price.* For comparable performance, G-E Thymotrol drives cost you less! See your G-E Apparatus Sales engineer today—or—write Sect. 791-5, General Electric Co., Schenectady 5, N. Y. *Specialty Control Dept., Waynesboro, Virginia.*

†1 HP, 440-volt, AC input, general-purpose Thymotrol drive.

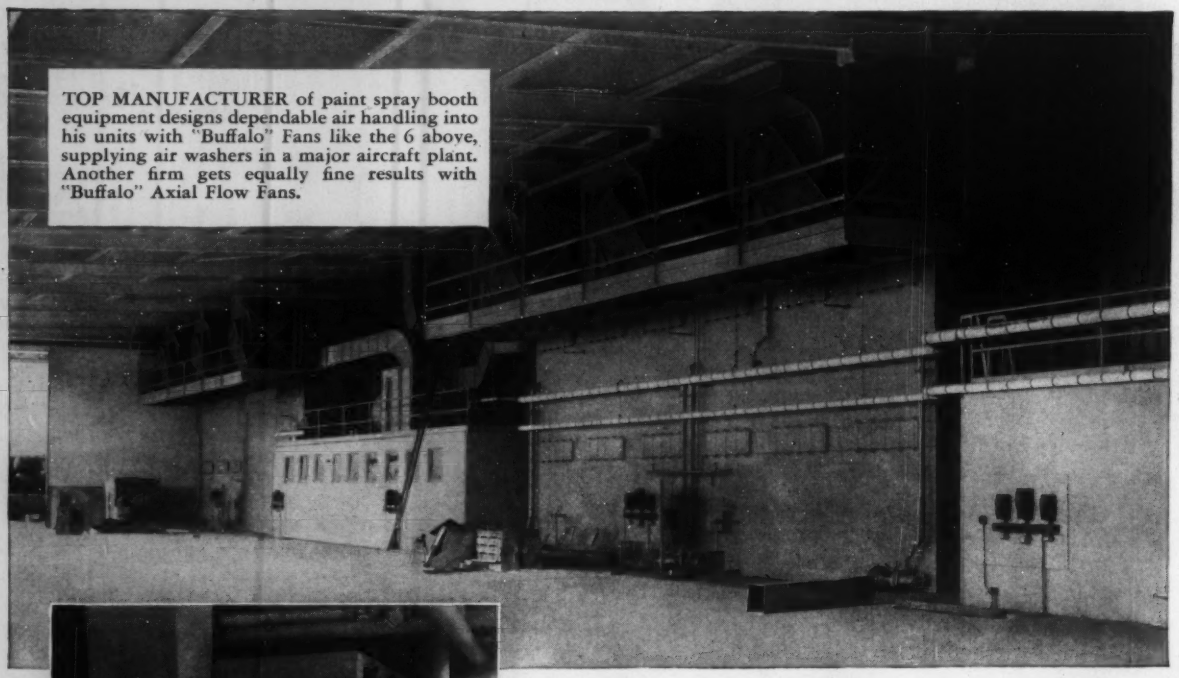
GENERAL ELECTRIC

COMPARE AND PROVE SUPERIORITY OF G-E THYMOTROL DRIVES

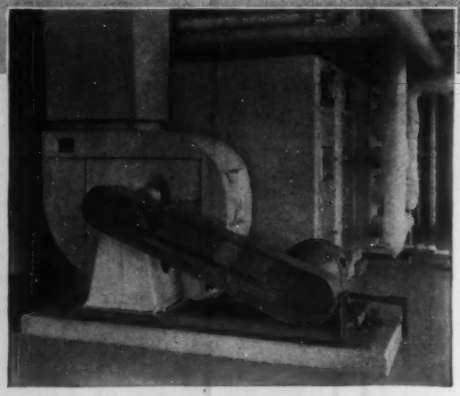
FEATURES	G-E THYMOTROL DRIVE	DRIVE A	DRIVE B	DRIVE C	DRIVE D
Swingout panels for easy maintenance	✓				
Printed circuitry	✓		✓		
Remote torque control	✓			✓	
Both half-wave and full-wave models	✓				
Speed range of 8 to 1 or more	✓	✓	✓	✓	✓
Regulation of 5% or less	✓		✓	✓	

Circle 458 on page 19

IF THERE'S A FAN IN YOUR PRODUCT

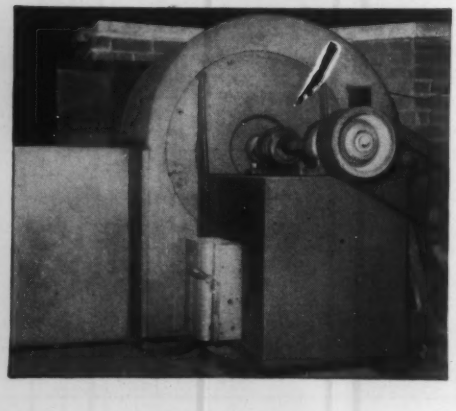


TOP MANUFACTURER of paint spray booth equipment designs dependable air handling into his units with "Buffalo" Fans like the 6 above, supplying air washers in a major aircraft plant. Another firm gets equally fine results with "Buffalo" Axial Flow Fans.



IN THE COUNTRY'S NO. 1 AIR CONDITIONING installations, you'll often find "Buffalo" Type "BL" Fans distributing the air.

LEADING BUILDER of tunnel kilns insures continuous top performance and long life with "Buffalo" Propeller and Centrifugal Fans.



MAKE IT "BUFFALO" FOR BEST RESULTS

For years, manufacturers of equipment embodying fans have relied on "Buffalo" for the efficiency and durability so necessary to successful performance of their equipment. You'll find everything from small "Buffalo" Blowers and Exhausters to high-capacity Type "BL" Centrifugal Fans serving equipment everywhere and serving it well.

First, "Buffalo" fanmanship, developed through 80 years in the business, means fan construction you can count on.

Second, the "Buffalo" line is complete. You can select the exact type and size to fit your product design — propeller fans, axial flow fans, centrifugal fans. And "Buffalo" has facilities to supply you with special designs to meet your most particular requirements. A talk with your nearby "Buffalo" Engineering Representative will bring out the proper fan to design into your product for results that make sales and reputation for you.

BUFFALO FORGE COMPANY

BUFFALO, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

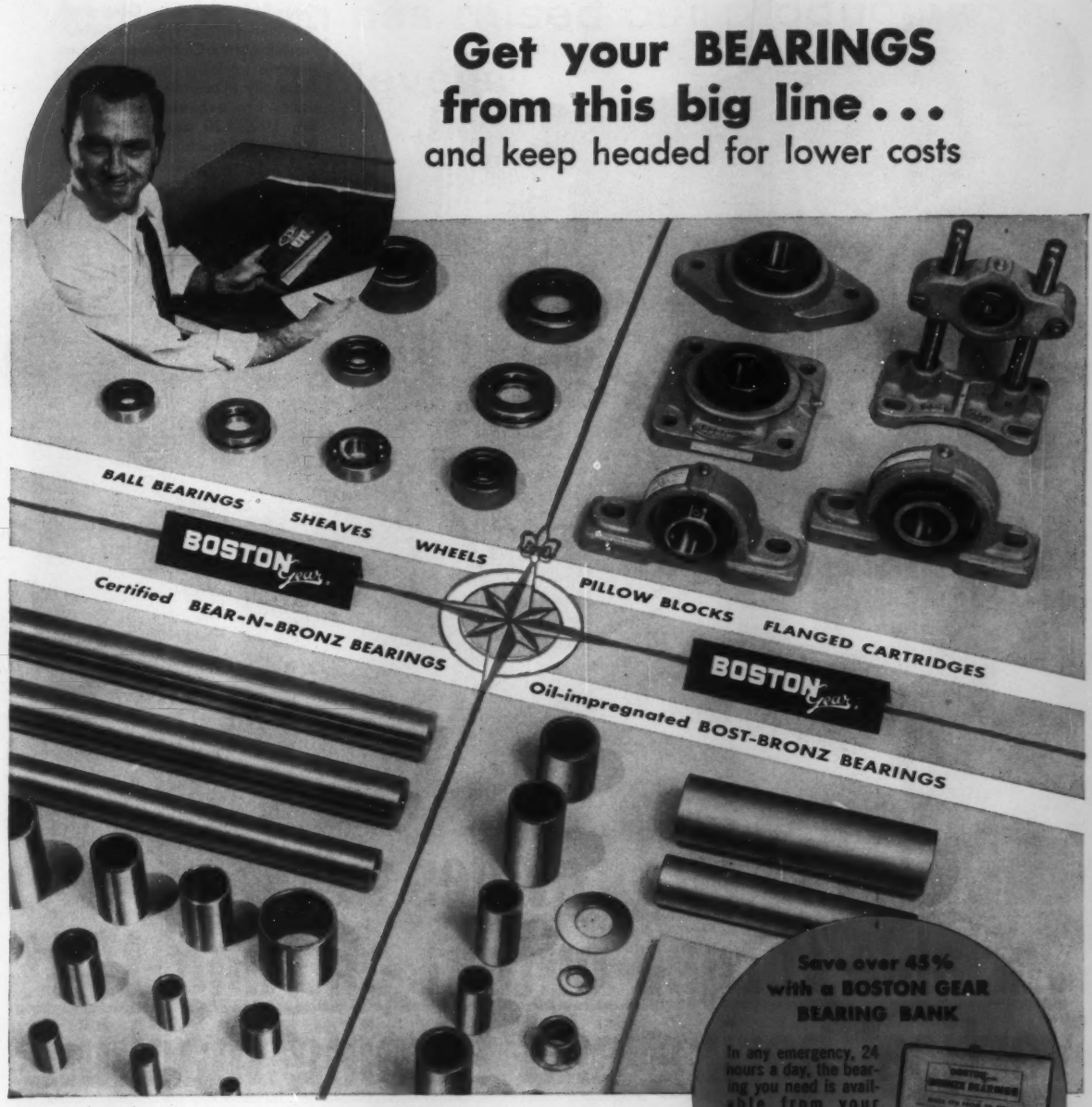
"Buffalo"

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING
FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Circle 459 on page 19

Get your BEARINGS from this big line...

and keep headed for lower costs



You'll find the bearing products you need among the thousands of types and sizes listed in the BOSTON GEAR Catalog No. 56. There is no finer quality, and you can get them faster . . . FROM STOCK — at your nearby BOSTON GEAR Distributor. Call him today, for prompt service. Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

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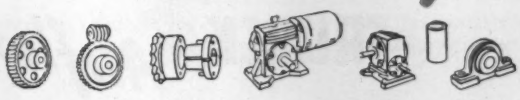
CALL YOUR BOSTON Gear DISTRIBUTOR



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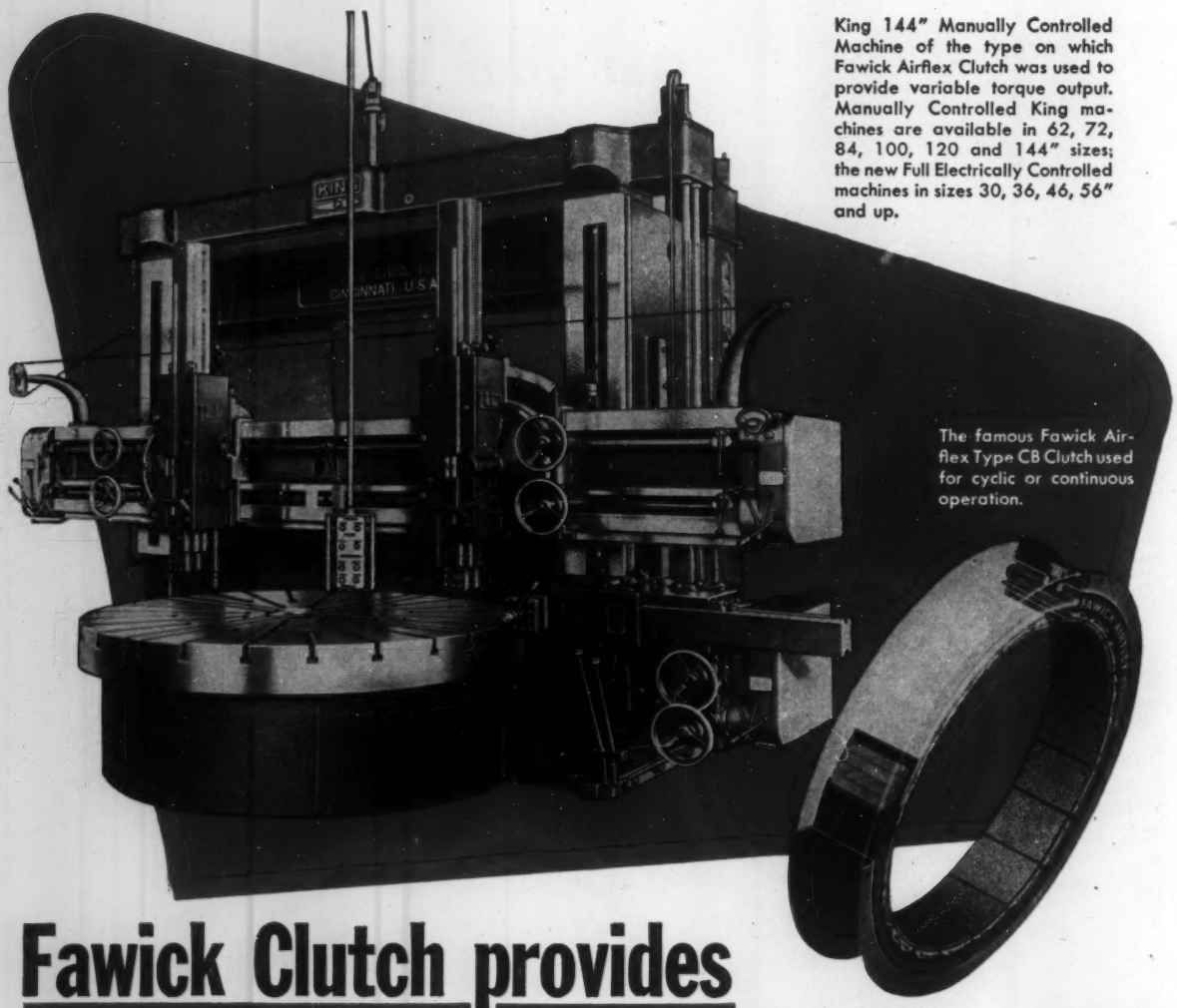
Save over 45% with a BOSTON GEAR BEARING BANK
In any emergency, 24 hours a day, the bearing you need is available from your "BANK". No costly delays. Bearings cost 46% less than if bought seperately.

"BANK" assortments available in BEAR-N-BRONZ or BOST-BRONZ, from your Distributor.



King 144" Manually Controlled Machine of the type on which Fawick Airflex Clutch was used to provide variable torque output. Manually Controlled King machines are available in 62, 72, 84, 100, 120 and 144" sizes; the new Full Electrically Controlled machines in sizes 30, 36, 46, 56" and up.

The famous Fawick Airflex Type CB Clutch used for cyclic or continuous operation.

Fawick Clutch provides variable torque output on King 144" vertical boring and turning machine

The King Machine Tool Division, American Steel Foundries, recently solved a customer problem requiring a different machine torque output for each size work piece. This was accomplished on a King 144" manually controlled Vertical Boring and Turning Machine by installing a FAWICK Type 22CB500 Airflex Clutch between the drive motor and the machine drive.

When used for special work, torque output variations are established with simple regulation of the air pressure in the clutch. Under normal use, the clutch functions under full operating pressure as a coupling between the motor and the machine drive.

This is but one of hundreds of installations where FAWICK Airflex Clutches have solved special machine problems. Your nearest FAWICK representative will gladly demonstrate the advantages that FAWICK can provide for improving the performance and efficiency of your machines.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
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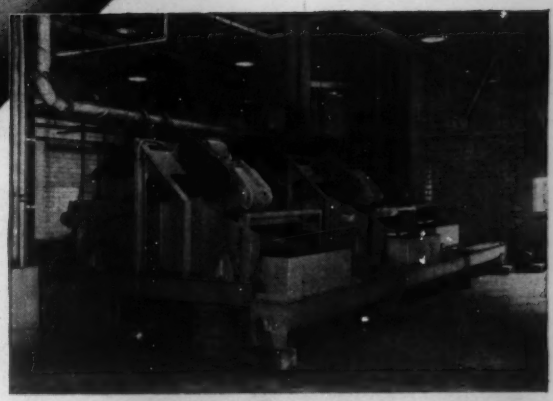
In Canada: Fawick Canada, Ltd., Toronto

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

Circle 461 on page 19

"Automation has raised our productivity to new high levels,"

reports a paper maker



Paper stock is automatically moved from this operation to the next by Jeffrey spiral conveyors.

JEFFREY
Spiral Conveyors

are a part of their automatically-controlled materials handling

• The high degree of automation recently introduced here has raised productivity per man to new high levels. Transfer of materials in process is largely under automatic control, for example, as evidenced by these Jeffrey spiral conveyor systems.

Jeffrey spiral conveyors offer an economical means of handling dry, loose bulk materials. Compact, they occupy a minimum of space. Convenient, they can be fed or discharged at any point along their length. Jeffrey makes them in open and dust-tight styles, of metals to suit particular requirements.

When adapting spiral conveyors to your products, ask Jeffrey engineers for their recommendations and assistance. Catalog 851 describes the various types available to you. The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

JEFFREY

Circle 462 on page 19

Dayton Variable Speed Cog-Belts* make possible Unique Drive for New 1957 RCA WHIRLPOOL Washer-Dryer Combination

Whirlpool Corporation turned to Dayton with a revolutionary new drive design for their RCA WHIRLPOOL Washer-Dryer Combination. What they proposed was a variable speed V-Belt transmission to replace the conventional gear case. Potential benefits to users of the Washer-Dryer Combination was a smoother, more readily adjusted, quieter running drive, and lower operating costs.

Dayton V-Belt Engineers analyzed the design, then recommended Dayton Variable Speed Cog-Belts* and furnished samples for initial testing. These first tests proved that the design would work and that the specially designed Dayton Cog-Belts were non-dusting, flexible enough to work over small diameter sheaves, and would pick up the load smoothly and without slipping.

From then on, engineers for both Dayton and Whirlpool worked as a team through the design, redesign and production design stages with Dayton furnishing new samples at each stage. Not only was the design perfected through this coordinated activity but it was mechanically simplified and its cost reduced.

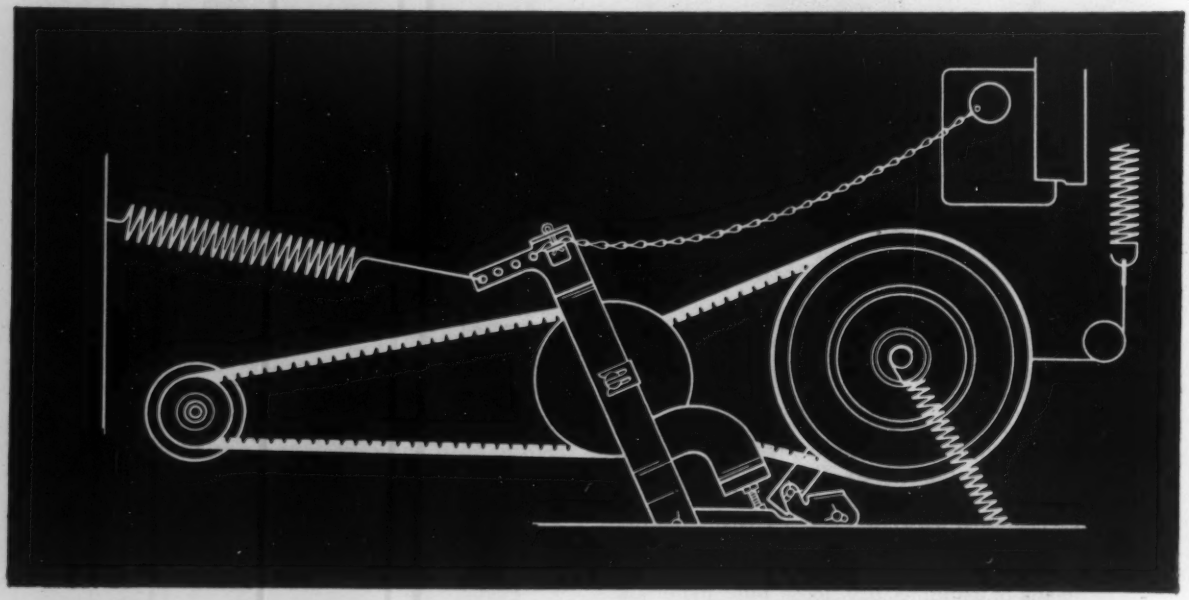


FIGURE 1—RCA WHIRLPOOL Washer-Dryer Combination with back panel removed showing variable speed drive controls.

The final design, now in production, (Fig. 1) employs a simple, single-speed motor to drive the cylinder at both tumble and spin speeds and completely eliminates the conventional geared transmission. Essentially, the drive is composed of a unique variable speed sheave assembly and two plate-finished Dayton Variable Speed Cog-Belts.

The sheave assembly (Fig. 2) has a sliding center section, and is mounted in a pivoted bracket. Movement of the bracket, and control of the speed ratio, is through a speed control motor connected to the bracket by a chain.

During all wash, rinse and tumbling cycles (Fig. 3), the sheave assembly is held in low drive by a pull-back spring.

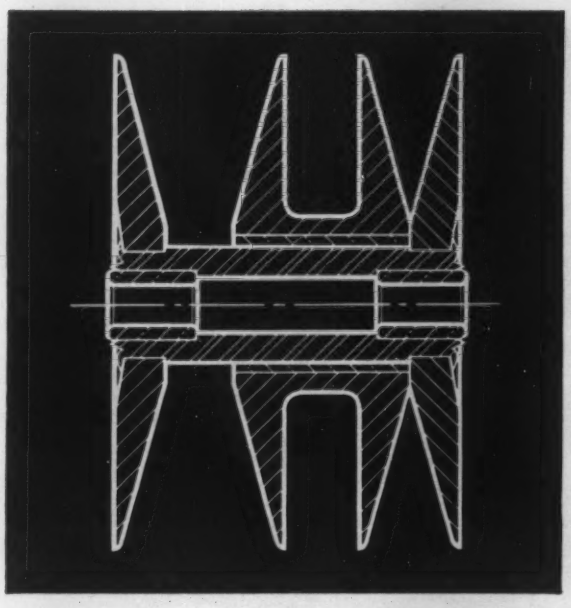


FIGURE 2
Exploded view of variable speed sheave assembly.

Cylinder speed during the low drive cycles is 45 rpm.

During the spin-dry cycle (Fig. 4), the speed control motor is actuated and, by taking-up the linking chain, causes the bracket to pivot. As the bracket moves, tension is increased on the primary belt and decreased on the secondary belt, causing the center section to move sideways. As tension is equalized by the movement of the center section of the sheave, the primary belt pulls deeper into the sheave and the secondary belt is forced away from the sheave axis. The ratio change thus effected produces a resultant speed of 200 rpm.

Another tremendous advantage of the design is that it is infinitely variable within the assigned limits. Thus, it is possible, by the addition of a delayed-reset switch and a simple control arm, to interrupt the speed change at any point, if vibration is created by an out-of-balance load. The result is positive, automatic load balancing.

Here is how this feature operates. When an excessive out-of-balance condition exists, the excursion switch arm trips the excursion switch. This breaks the circuit to the speed control motor for approximately 13 seconds — during which time the pull-back spring returns the drive to tumble speed and the load redistributes itself. When 13 seconds have elapsed, the switch automatically resets and the drive again shifts into the high range. If necessary, there can be unlimited "hunting" for a balanced condition before the cylinder reaches 200 rpm, the normal spin-dry speed.

While complex and difficult to describe, the load balancing operation is so smooth that it is hardly perceptible. This is due to the special design and construction of Dayton Raw-Edge Cog-Belts.

Dayton's experienced Engineers are ready to assist you in solving your special V-Belt design problems. To contact them, or for more information about Dayton Raw-Edge V-Belts, write The Dayton Rubber Company, Industrial O.E.M. Division, Dayton 1, Ohio.

FIGURE 3
Variable speed drive during tumble cycle. Cylinder speed is 45 rpm.

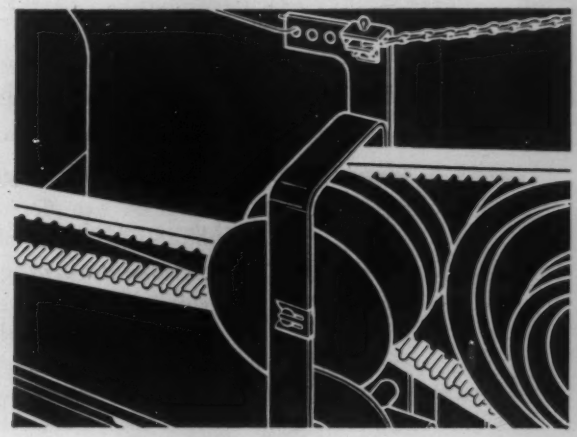


FIGURE 4
Variable speed drive during spin cycle. Cylinder speed is 200 rpm.

THE DAYTON RUBBER COMPANY, INDUSTRIAL O. E. M. DIVISION, DAYTON 1, OHIO

Dayton Rubber

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When product designers send preliminary drawings for critical review by the seasoned Madison-Kipp mechanics, it has often proved to be the decisive factor in the ultimate design of the component parts.

The original designer thoroughly understands the function of his product. We thoroughly understand die casting and machining problems. Combining the two skills at an early period of development is logical and valuable.

Our customers of long standing always utilize this system which virtually pyramids design talent for successful high production manufacturing.

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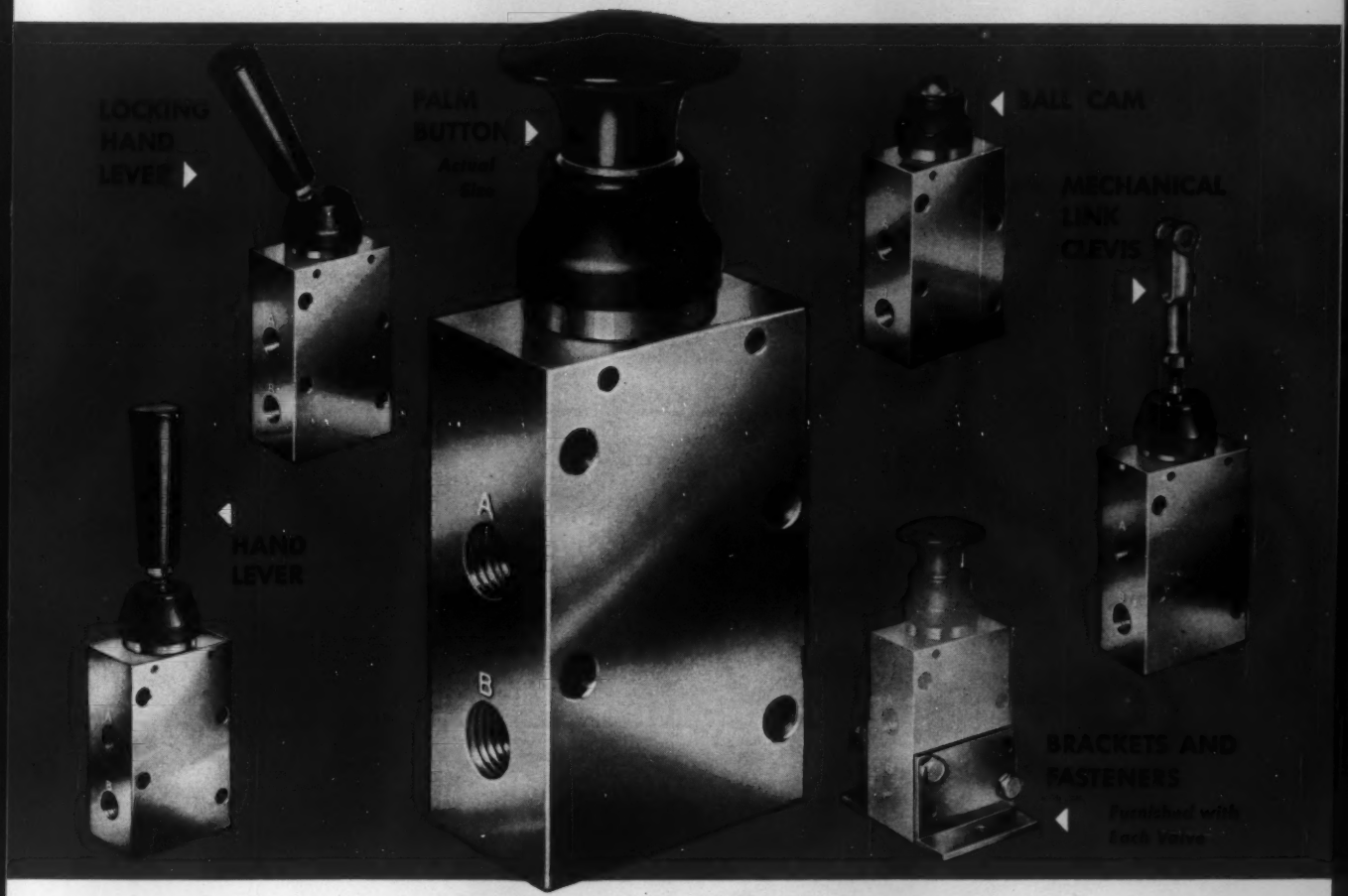
Circle 464 on page 19

NEW HANNA FLO-PILOT VALVE has dirt-proof seal!



Hanna Flo-Pilot Valves are ¼" two- and three-way Pilot Valves for air operation to 150 psi. They are used for remote control of master valves, directional control of small single acting cylinders and for shut-off. Same valve can be used for two or three-way operation either normally open or normally closed to inlet pressure.

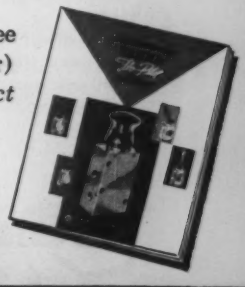
HANNA Flo-Pilot Valves will deliver years of dependable performance at a very low cost because they have built-in money-saving features. Every Hanna Flo-Pilot Valve is equipped with a synthetic boot which seals the valve stem and internal parts from harmful dirt and abrasive, thereby eliminating the most common cause of valve failure.

These protective boots, efficient "O" ring spool packing and nylon sleeves, are built into every Hanna Flo-Pilot Valve to save you money and assure leak-free operation even after millions of cycles.

The five actuating-heads—push button, ball cam, hand lever, locking hand lever and mechanical link clevis—are interchangeable in a matter of seconds. Spools can be changed just as quickly without disturbing the piping.

Corrosion resistant materials are used throughout. Flo-Pilot Valves have a simple, sturdy construction with anodized aluminum body, stainless steel and molded nylon parts. Valves can be conveniently mounted in any position and are furnished with brackets and fasteners. They are easy to operate, positive acting and have full capacity of ¼" orifices.

Ask your Hanna representative (see the yellow pages or Thomas Register) for complete information or *write direct for Catalog 262.*



Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

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Circle 465 on page 19

Eastman

First to be specified by America's leading OEM's

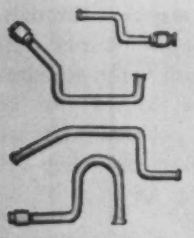
It's a known fact that many leading Original Equipment Manufacturers submit their original specifications for their *first* quotation to Eastman.

EASTMAN's unequalled experience in hydraulic conversion, plus many original designs shown in a few popular Eastman fittings at the right—give your product an appearance of quality that improves its competitive position in your field. It's a mark of distinction to be Eastman equipped!

EASTMAN Engineering Service . . . Backed by Unequalled Experience

It is also a known fact that Eastman's co-operative engineering counsel and service is highly respected and often requested by leading OEM's. Let Eastman engineers help you lay out your fluid power lines—from pump to point of work—effecting economies in design, improving performance and increasing user satisfaction.

Let EASTMAN recommend the *best assembly . . . for the best performance . . . at the lowest cost.*



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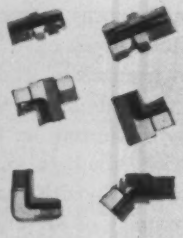

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Permanently Attached Male (NPTF) for 1, 2 and 3 wire braid rubber cover hose, and 4 spiral wire extra high pressure hose.
Sizes: 3/16" thru 3".
Wkg. pressure: 375—5000 p.s.i.

Permanently Attached Male Flare (JIC) for 1, 2 and 3 wire braid rubber cover hose.
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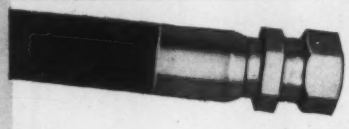
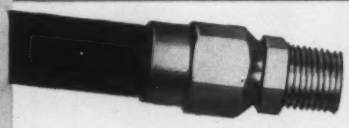
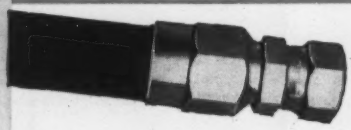


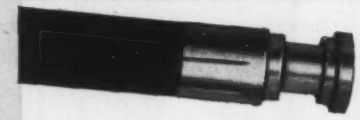
Permanently Attached Swivel Female for 1, 2 and 3 wire braid rubber cover hose.
Sizes: 3/16" thru 2".
Wkg. pressure: 375—5000 p.s.i.



Reusable Male (NPTF) for rubber and cotton cover hose.
Sizes: 3/16" thru 1 3/16".
Wkg. pressure: 375—5000 p.s.i.



Reusable Swivel Female for rubber and cotton cover hose.
Sizes: 3/16" thru 1 3/16".
Wkg. pressure: 375—5000 p.s.i.



Permanently Attached Flanged Head Couplings for 1 and 2 wire braid rubber cover hose.
Sizes: 1/4" thru 2".
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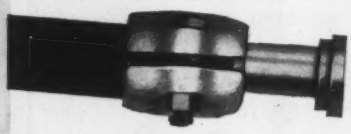

Clamp Type Coupling with split flange stems for 1 and 2 wire braid rubber cover hose.
Sizes: 1/4" thru 2".
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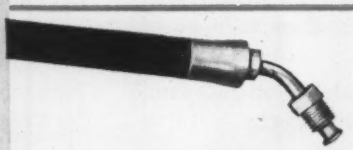

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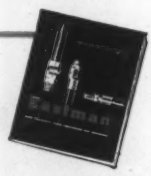

AT CHICAGO BLOWER COMPANY

DIEHL motors increase product acceptance

To back up their reputation for first-quality design and workmanship in the manufacture of heating ventilating, air-conditioning and exhaust systems, Chicago Blower Company Chicago, Ill., relies on top-flight manufacturers for certain equipment components

"Insofar as the all-important power drive is concerned", says Chicago Blower's President, Fred H. Gohl," . . . we feel we are giving our customers the very best when we give them a DIEHL motor."

In more than ten years of DIEHL motor use, Mr. Gohl knows of no instance in which there has been a failure. And he is enthusiastic about the nationwide chain of DIEHL authorized service stations which are never farther away than the nearest telephone if maintenance or repairs should be needed. These two factors, he says, have definitely contributed to the increased acceptance of their products and explains why Chicago Blower is a consistent user of DIEHL motors.

This is another example of how a forward-looking manufacturer turned to DIEHL for help in building equipment of superior design and performance. With almost three-quarters of a century of experience in producing better motors for varied classes of industry, DIEHL will gladly help you meet *your* motor needs. We will work closely with you to provide the right motor—at the right time—at the right price.

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Circle 467 on page 19

In Leland submersible pump motors

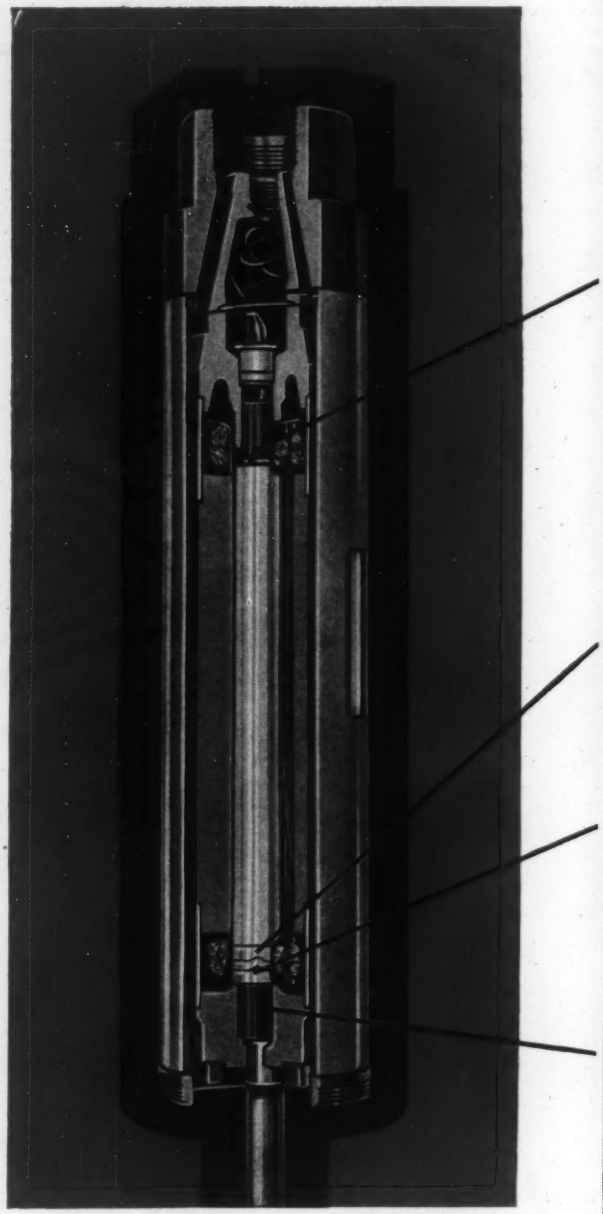
GRAPHITAR® and GRAMIX®

(CARBON-GRAPHITE) (PRODUCTS OF POWDER METALLURGY)

operate with gasoline

as the only

lubricant!



Running directly in gasoline, this superbly-designed Leland submersible motor embodies two GRAMIX thrust washers and two GRAPHITAR bearings to keep the operation of this amazing explosion-proof pump motor safe and smooth.

Thirty years ago the manufacturer of these pumps—the Leland Electric Co., Dayton, Ohio, a division of American Machine and Foundry Co., developed the first gasoline curb-pump motor to receive Underwriters' Laboratories' approval. Throughout their long experience, they have selected every component with great care. It is thus significant that for Leland's submersible motor they selected GRAPHITAR and GRAMIX bearings.

GRAPHITAR is a non-metallic, carbon-graphite material that will not weld or score even when in contact with a metal shaft. Any liquid will act as a lubricant, thereby reducing friction and increasing service life. With low-viscosity liquids such as gasoline, friction is at a minimum because of the low film strength.

GRAMIX, tough, long-wearing sintered-metal, has an extremely high particle hardness and excellent surface finish; can be precision die-pressed to tolerances within .0005". GRAMIX parts can withstand incredible amounts of pounding action. These factors, coupled with their extremely low cost, have helped add to the increasing use of GRAMIX parts in many industries.

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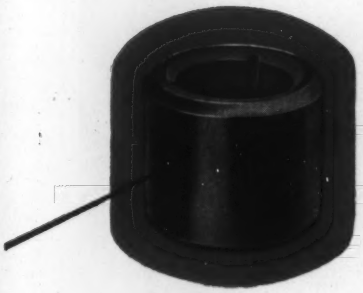

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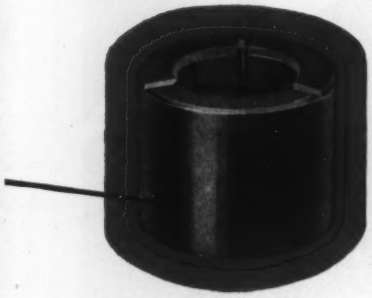
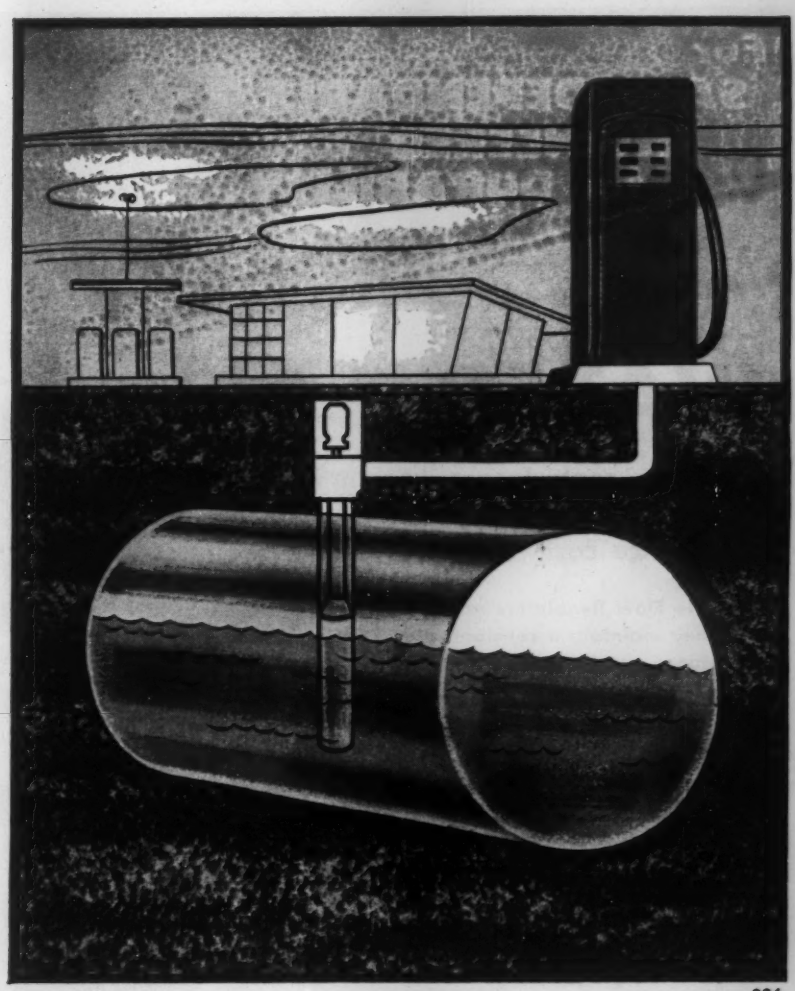
GRADE 14
RADIAL BEARING

GRAMIX STEEL
THRUST BEARING
DRIVE

GRAMIX HARDENED
STEEL THRUST PLATE



GRAPHITAR RADIAL
AND THRUST BEARING



236

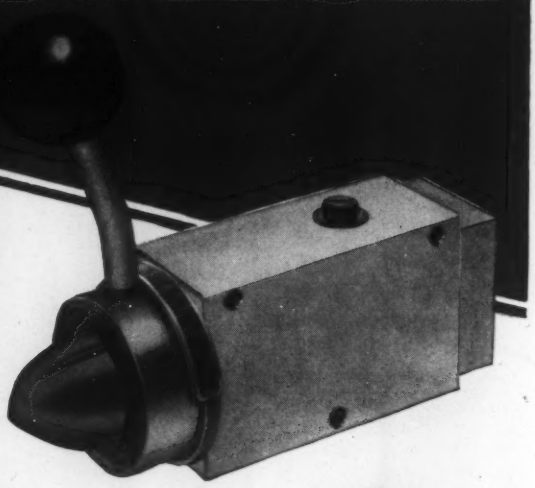
Write today for these two new engineering bulletins, GRAPHITAR Bulletin No. 20 and GRAMIX Bulletin No. 21.

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Circle 468 on page 19

For SAFE, DEPENDABLE ENGINEERED for DURABILITY... CONTROLS



CONSULT WATERMAN

Waterman controls are known for their accuracy, dependability, safety, and low maintenance cost.

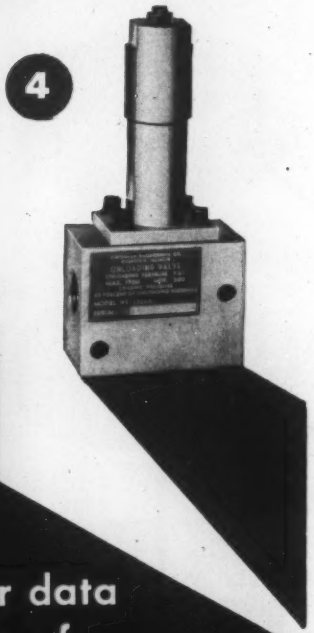
Adjustable Flow Regulators range from 0.5 GPM to 20 GPM. They maintain a constant rate of flow regardless of resistance or pressure fluctuations.

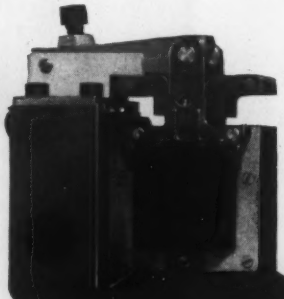
No. 1 Check Valves are one piece, Nylon Poppet, aluminum body and low pressure drop.

No. 2 Micronic Line Filters have operating pressures to 3000 psi, 40 micron filtration, replaceable elements, and are available in ⅜" and ¾" NPT.

No. 3 Solenoid Valves are inexpensive, compactly built units for hydraulic systems handling non-corrosive fluids. Capable of continuous operation for working pressure to 3000 psi.

No. 4 Unloading Valves for pressures to 3000 psi. Flow rates to 30 GPM. Fast acting, maintain desired pressure without continuous readjustments.



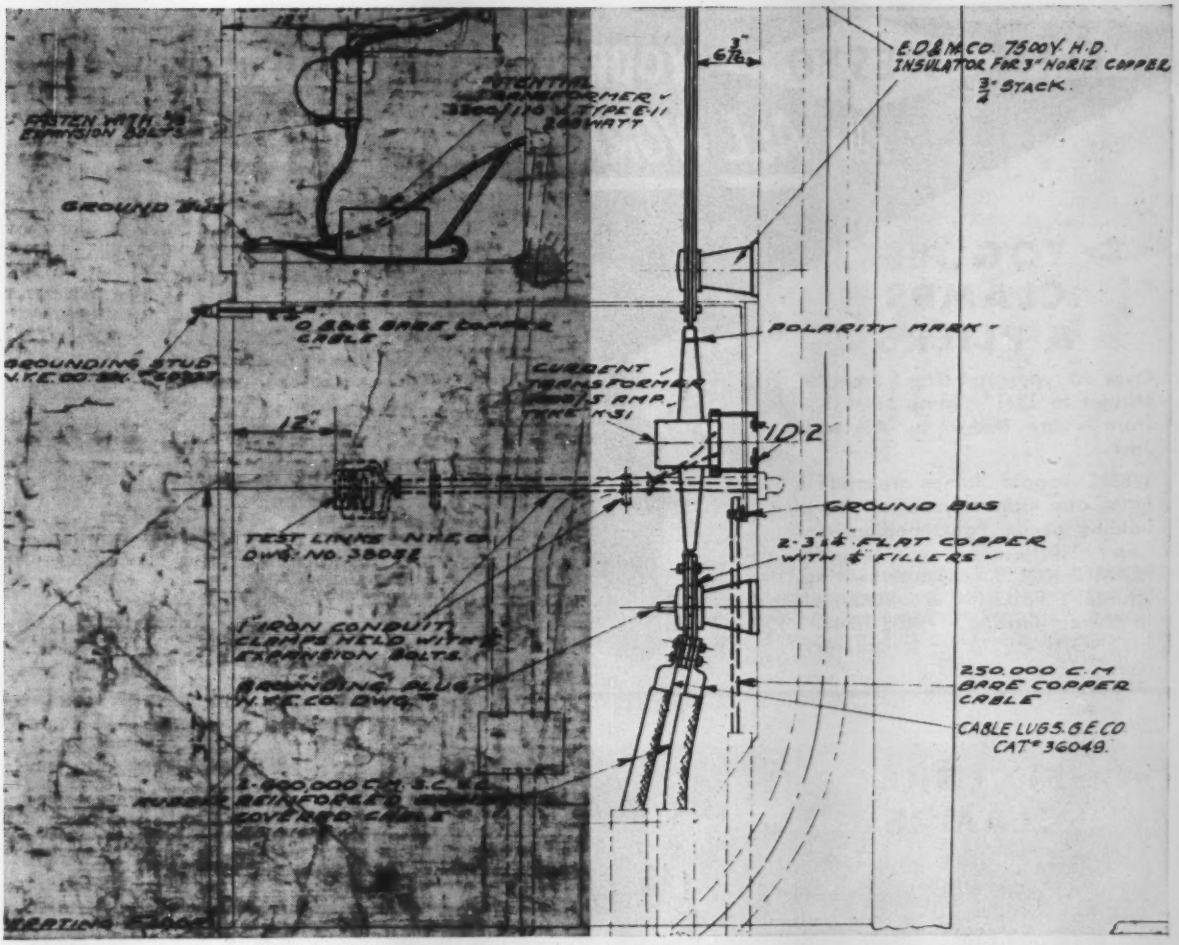


Send for Bulletin E

Write for data on any of these WATERMAN products

WATERMAN ENGINEERING COMPANY

725 CUSTER AVENUE EVANSTON, ILLINOIS


E.D.&M.CO. 7500V. H.D. INSULATOR FOR 3" HORIZ. COPPER
3" STACK.
POLARITY MARK
GROUND BUS
2-3" x 1/4" FLAT COPPER WITH 5/8" FILLERS
250,000 C.M. BARE COPPER CABLE
CABLE LUGS G.E.CO CAT. 36049.
GROUND BUS
GROUNDING STUD
TEST LINKS N.H.E.C. DWG. NO. 38088
1" IRON CONDUIT CLAMPS HELD WITH EXPANSION BOLTS.
GROUNDING PLUG W.E.C.O. DWG.
12"
10-2

How to get better copies of your drawings

Here are two white prints spliced together for your comparison. The copy on the left was made from a sensitized cloth intermediate. This intermediate, and the print produced from it, bear the same scars of age and wear as the old original drawing.

To make the copy on the right, the worn original was reproduced on CRONAFLEX, Du Pont's amazing new engineering reproduction film. See how the CRONAFLEX intermediate has eliminated the kink marks, cleaned up the smudging, actually improved the drawing.

CRONAFLEX improves the copies of your drawings for several reasons. First, the physical characteristics of the films eliminate the kink and smudge marks from the prints. Second, the high contrast of CRONAFLEX gives you better intermediates, which means more legible blue or white prints. Third, because of the unexcelled matte surface of CRONAFLEX, you can do additional drafting or make corrections on "second originals" quickly, easily, and accurately.

CRONAFLEX engineering reproduction films are extremely versatile. They are available in three types: Direct Positive, Contact and Projection. All CRONAFLEX films are on Cronar® base, assuring unbelievable ruggedness, high dimensional stability, minimum moisture absorption.

CRONAFLEX will not tear, kink, shatter or become brittle with age or handling. CRONAFLEX has a matte finish that provides the finest pencil or ink acceptance. Lines do not smudge. Reproductions are cleaner, sharper, more legible.

Shouldn't you specify CRONAFLEX for your intermediates and "second originals"?

FOR MORE INFORMATION on CRONAFLEX, write to: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada (1956) Limited, Toronto.

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Better Things for Better Living
. . . through Chemistry

DU PONT CRONAFLEX
TRADEMARK
for Functional Photography

Photography with a purpose . . . not an end in itself, but a means to an end.

Circle 470 on page 19

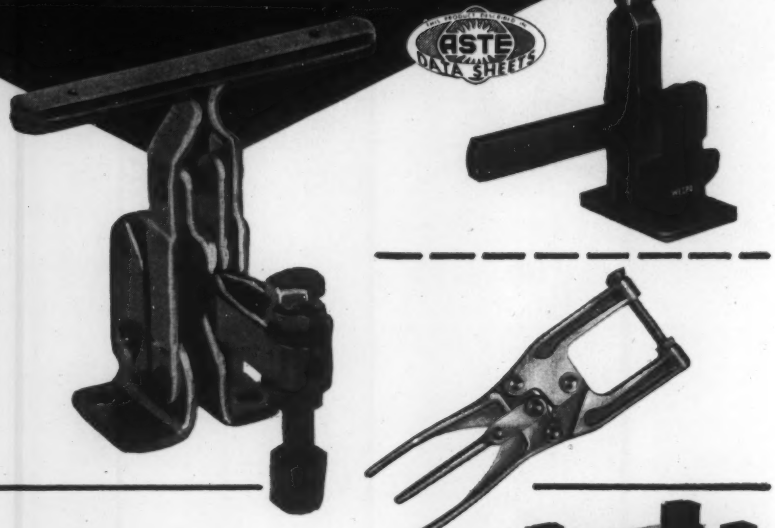
MAKE WESPO YOUR DESIGN STANDARD for ALL WORKHOLDING NEEDS

ASTE DATA SHEETS

WESPO TOGGLE CLAMPS & PLIERS

Over 80 types and sizes. From 3/8" Midget to 12 3/8" Clamp. PLIERS — from 1 3/16 Jaw Midget to 4 1/4 wide Jaw.

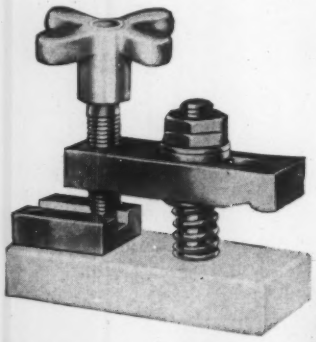
WESPO Toggle Clamps are made in types and sizes to meet all workholding needs, light, medium and heavy duty. Features include: REAMED HOLES, for better bearing, HARDENED BUSHINGS — SERRATED to prevent turning — HIGH TENSILE STRENGTH RIVETS for longer service.

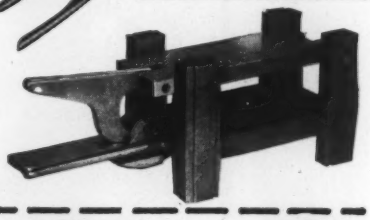


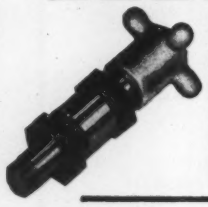
WESPO FIXTURE CLAMPS

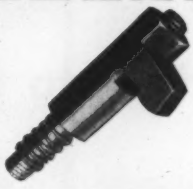
Over 170 Types and Sizes

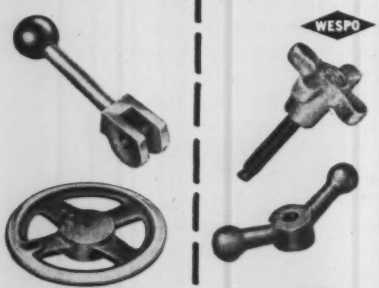
WESPO fixture clamp assemblies save up to 70 percent on your own designing and machining. They are used as standard by a large number of leading manufacturers.







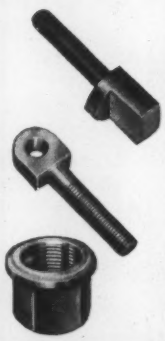


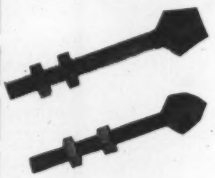


WESPO COMPONENTS

Over 1,000 types and sizes available from stock.

WESPO parts are precision manufactured of quality steel — heat treated and rust-proofed. They are designed for heavy duty and long wear and have proved their value in many industries.





ADJUSTABLE SPINDLES FOR TOGGLE CLAMPS with BONDED NEOPRENE CAPS

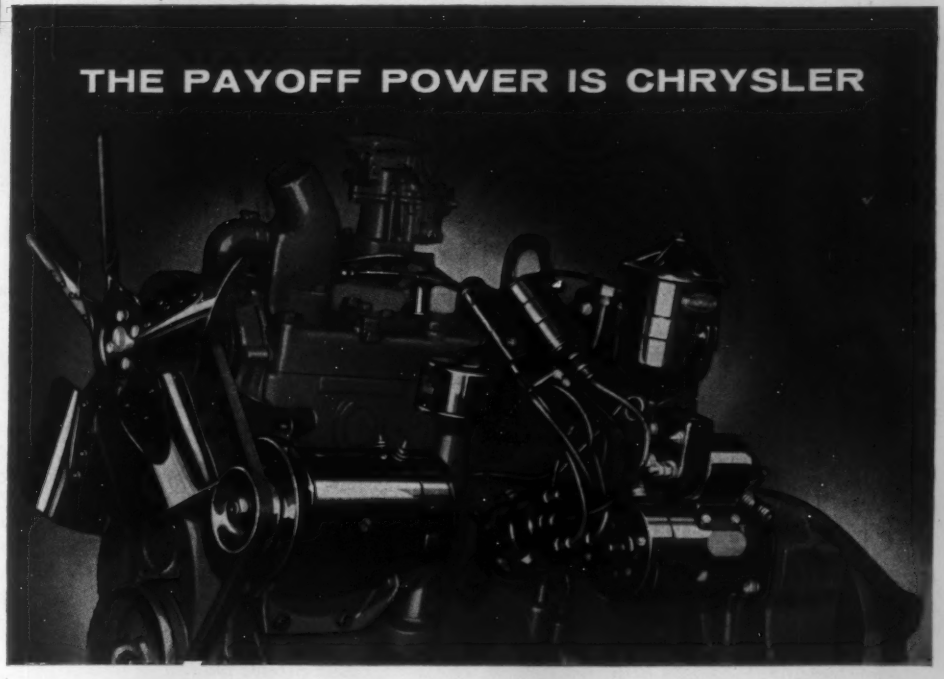
Write for Catalogs —
TOGGLE CLAMPS & PLIERS, FIXTURE CLAMPS and PARTS

WEST POINT MFG. CO.
26941 W. 7 Mile Road • Detroit 19, Michigan

Circle 471 on page 19

Crane-of-all-work

THE ROUSTABOUT—manufactured by the Hughes-Keenan Corporation—is a highly versatile, highly maneuverable motive crane. It has an extremely short turning radius, travels at speeds up to 15 m.p.h. All three crane operations—swinging the boom, raising and lowering the boom, working the hoist line—can be performed simultaneously or independently. All six models (5 ton capacity shown) can be specially equipped for construction work, in-plant or out-plant materials handling. To assure maximum power efficiency and dependability, Roustabout Cranes are powered by big-output, heavy-duty Chrysler Industrial Engines.



CHRYSLER INDUSTRIAL 30

(230 cu. in. displacement) powers the 3, 4, 5, 6 ton models of the Roustabout Crane. (Industrial 32, 265 cu. in. displacement powers 10, 12½ ton models.) Both of these in-line six engines also power many other makes of equipment in the construction and materials handling fields. There are four Chrysler in-line 6s, two V-8s—ranging from 230 to 354 cu. in. displacement.

Chrysler
INDUSTRIAL ENGINES
INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

Write Dept. C10, Industrial Engine Division, Chrysler Corporation, Detroit 31, Michigan, or see your nearest Chrysler Industrial Engine Dealer.
☐ For engineering information ☐ For descriptive literature

NAME

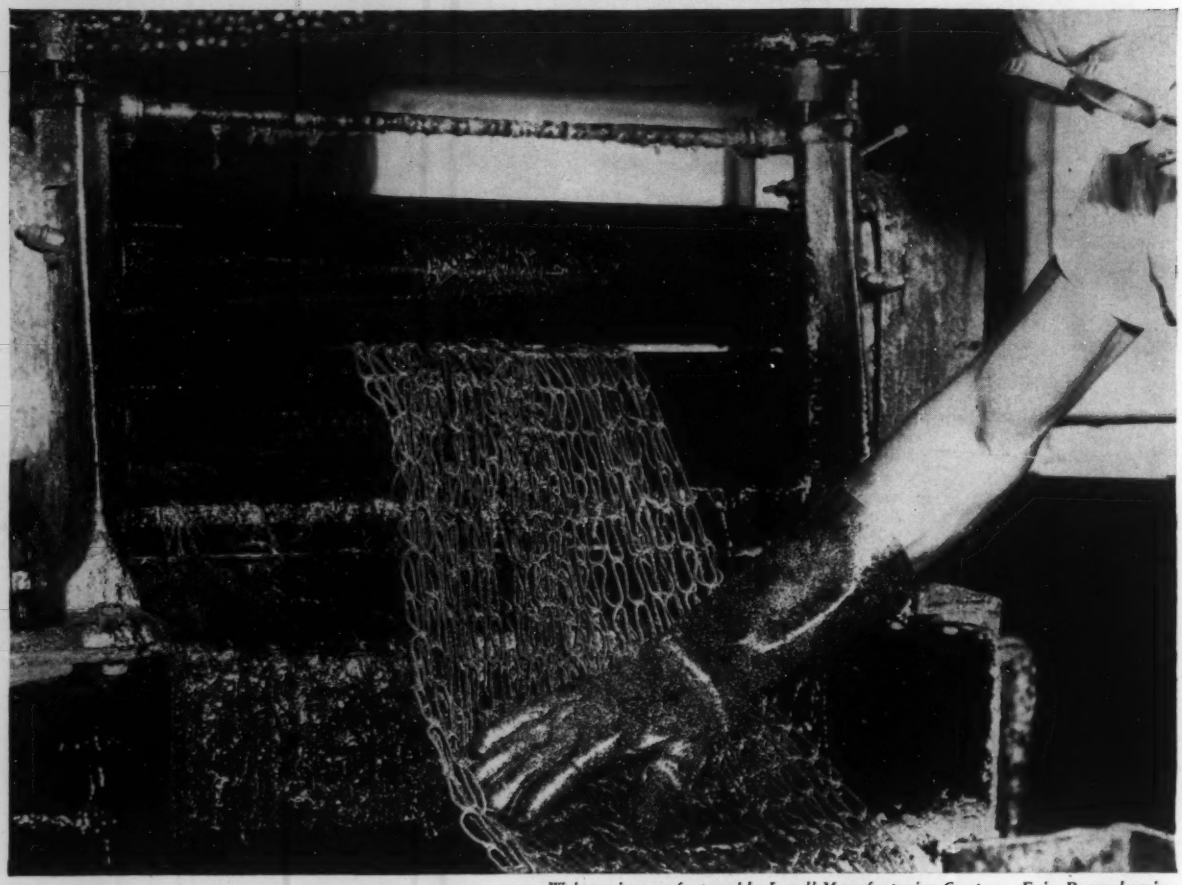
ADDRESS

CITY ZONE STATE

Circle 472 on page 19

News about

B.F.Goodrich Chemical *raw materials*



Wringer is manufactured by Lovell Manufacturing Company, Erie, Pennsylvania. This installation is at The Fishermen's Supply Co., Inc., Tampa, Florida.

Hycar nitrile rubber rolls squeeze the tar out of shrimp nets

SO they can fight off salt water, shrimp nets are treated with tar before they are ever dipped in the deep. Squeezing the excess tar out of these nets is a job for special wringer rolls made of Hycar nitrile rubber.

The reason? Tar kills ordinary rubber but it has no effect on Hycar. This rubber stands up to hydrocarbons like tar, crude oil, gas and gas distillate.

Hycar withstands high pressures and resists deterioration by salt water and steam. Its surface is tough and abrasion resistant. It resists aging; provides high strength, shock and vibration resistance and flexibility at high and low temperatures.

With Hycar nitrile rubber *you* can improve product performance in environments where ordinary rubber can't survive. For information, write Dept. HK-5, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
Reg. U.S. Pat. Off.
American Rubber

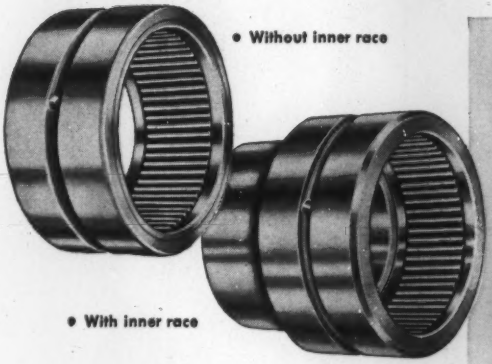
B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

ORANGE NEEDLE BEARINGS

—offer widest choice of types and sizes to match your design needs

—greater opportunity to simplify design—fight friction—meet load requirements—save space and cost.



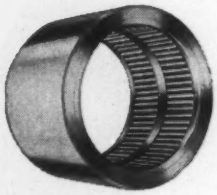
• Without inner race

• With inner race

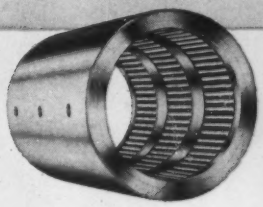
ORANGE *Full Type* ROLLER BUSHINGS

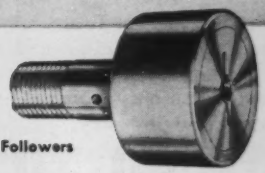
Maximum load capacity in small space

Orange Roller Bushings are full-type needle bearings for heavy-duty service. Rollers and races made of finest bearing steel—hardened, ground and finished to highest precision standards for durable, friction-free operation. Exacting control of roller uniformity by electronic gauging, permits closer internal running clearances, minimizing possibility of misaligned rollers. Complete range of stock sizes from ½" to 8" shaft diameters.



• Two and three row types for extra heavy duty





• Cam Followers

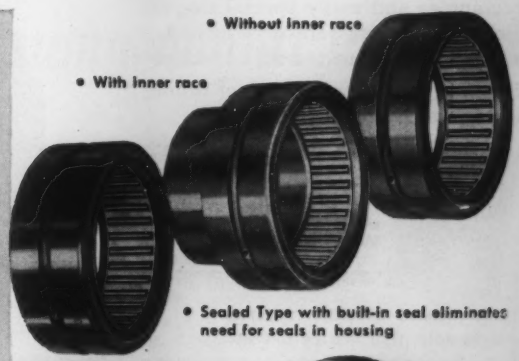
ORANGE *Cage Type* NEEDLE BEARINGS

Permanent alignment of rollers prevents skewing

Anti-friction cage keeps rollers permanently aligned and true-running in any position—vertical, tilted, horizontal. Successful on overhung mountings and relatively high-speed installations. Less affected by misaligned mountings or uneven loading. Extremely smooth, quiet running. The answer to many applications unsuited for conventional needle bearings. Wide choice of sizes from ½" to 8" diameter.

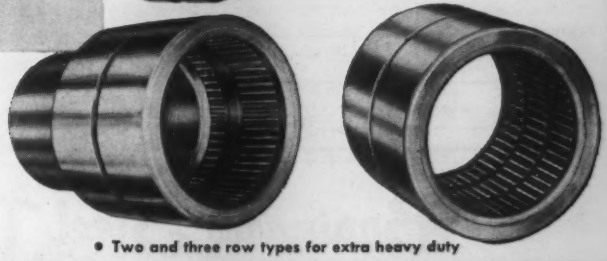
• Without inner race

• With inner race



• Sealed Type with built-in seal eliminates need for seals in housing

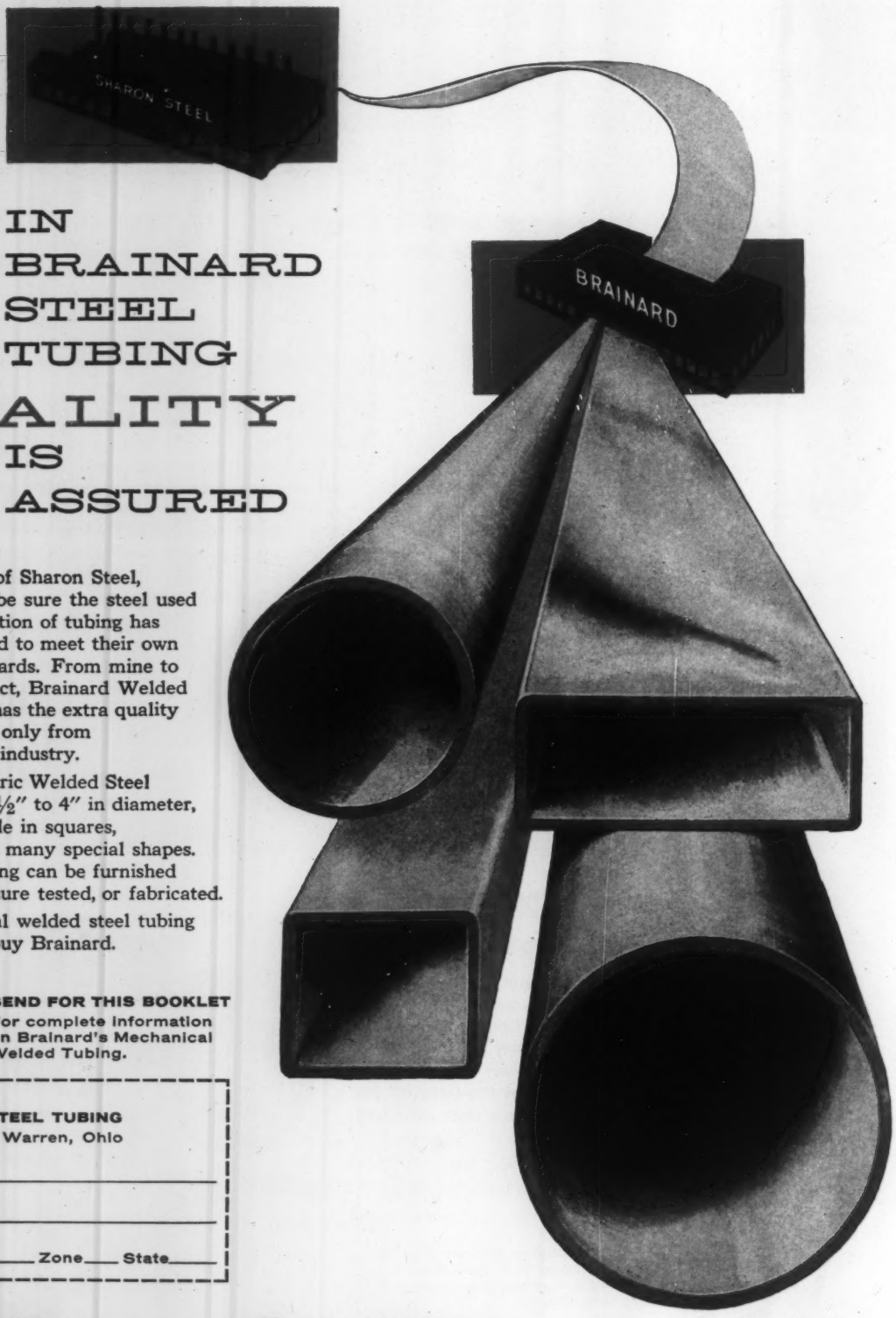
WRITE for new 40-page Engineering Reference Manual M-55 giving complete details of construction, dimensions, capacities, etc.



• Two and three row types for extra heavy duty

ORANGE ROLLER BEARING CO., INC., 556 Main Street, Orange, N. J.

Circle 474 on page 19



IN BRAINARD STEEL TUBING QUALITY IS ASSURED

As a division of Sharon Steel, Brainard can be sure the steel used for the fabrication of tubing has been developed to meet their own exacting standards. From mine to finished product, Brainard Welded Steel Tubing has the extra quality that can come only from an integrated industry.

Brainard Electric Welded Steel Tubing, from ½" to 4" in diameter, is also available in squares, rectangles and many special shapes. Brainard Tubing can be furnished swedged, pressure tested, or fabricated.

For mechanical welded steel tubing of top value, buy Brainard.

SEND FOR THIS BOOKLET
For complete information on Brainard's Mechanical Welded Tubing.

BRAINARD STEEL TUBING
Griswold St., Warren, Ohio

Name _____

Address _____

City _____ Zone ____ State ____

Brainard Steel Tubing

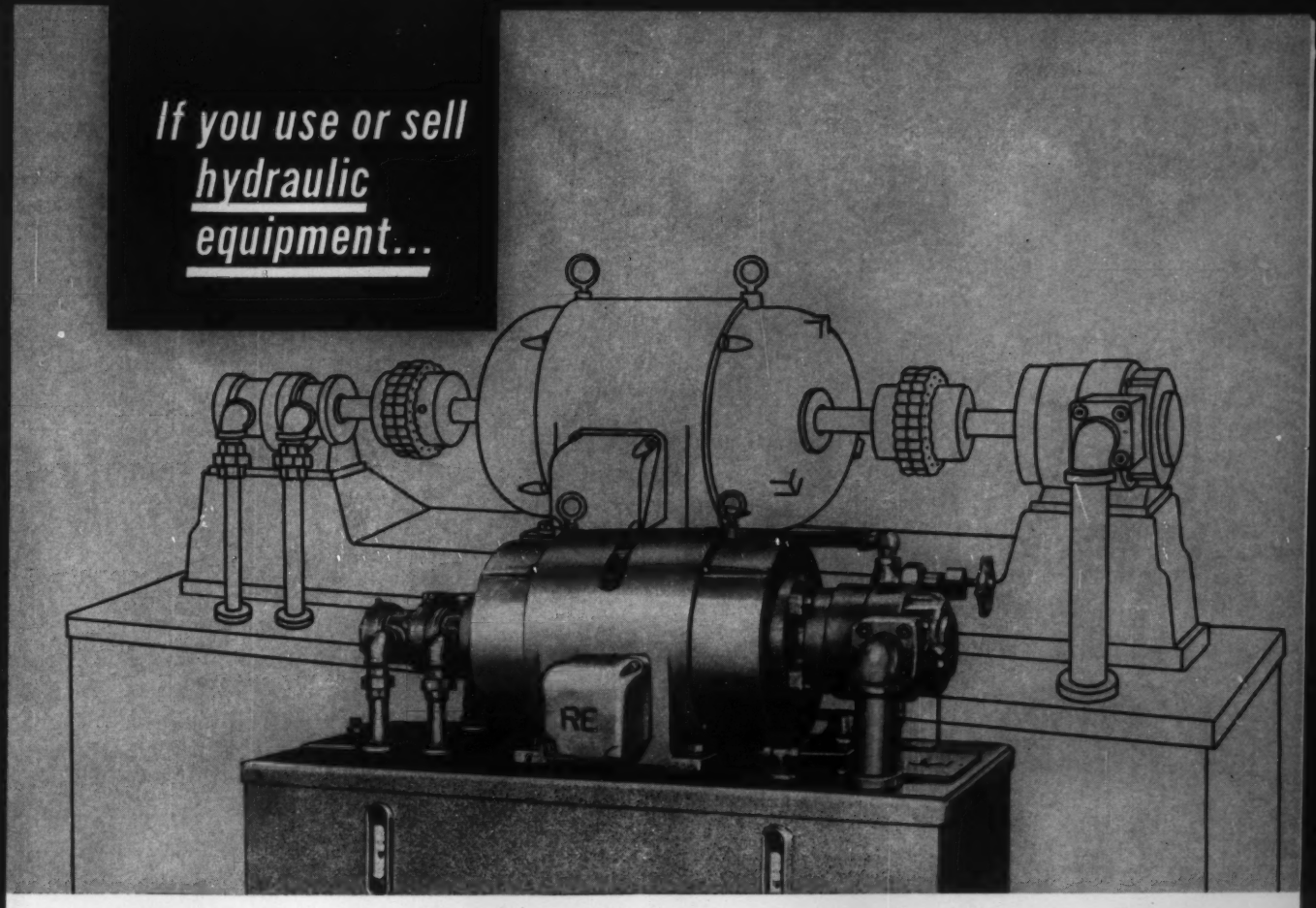
SHARONSTEEL

400

Brainard Steel Division, Sharon Steel Corporation
Griswold Street, Warren, Ohio

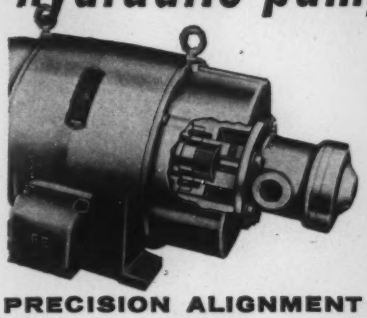
Circle 475 on page 19

If you use or sell hydraulic equipment...



...cut space needs almost 50% with REULAND spline-coupled hydraulic pump mount motors!

Pump and motor become *one* with the new Reuland spline-coupled hydraulic pump hook-up. The pump shaft is connected directly to the motor's shaft *inside the motor*. Flexible couplings are eliminated... pump mount platforms are eliminated... and the tank length can be reduced because almost 50% less mounting area is required. Compact appearance is beautiful.



SPEEDY INSTALLATION

Pump-to-motor hook-up is merely a matter of seconds. All you do is slip the spline coupling onto the pump shaft...and attach the pump to the endbell. This spline coupling is supplied with the motor and is precision mated for each make of pump. There's no time wasted tinkering around...takes only a fraction of the ordinary time.

PRECISION ALIGNMENT

Alignment is perfect *automatically* whether the installation is made out in the field or on the production line. This permits even unskilled workmen to handle this simple task without error. Also, by hooking the pump up at the point of bearing support, within the motor, vibration is reduced to a new minimum. Operation is smooth, quiet.

COSTS LESS...SAVES INSTALLATION LABOR... FITS ALL PUMPS

The Reuland spline-coupled unit is priced lower than a conventional set-up... saves you extra money by reducing installation costs. What's more, we can supply it to fit any make of pump you may be using. So sure are we that it will be of help to you, we are offering to engineer a demonstration unit to *your* equipment, without the slightest obligation. These units are our best salesmen.

OUR NEW GENERAL CATALOG WILL COME IN HANDY—SENT FREE ON REQUEST.

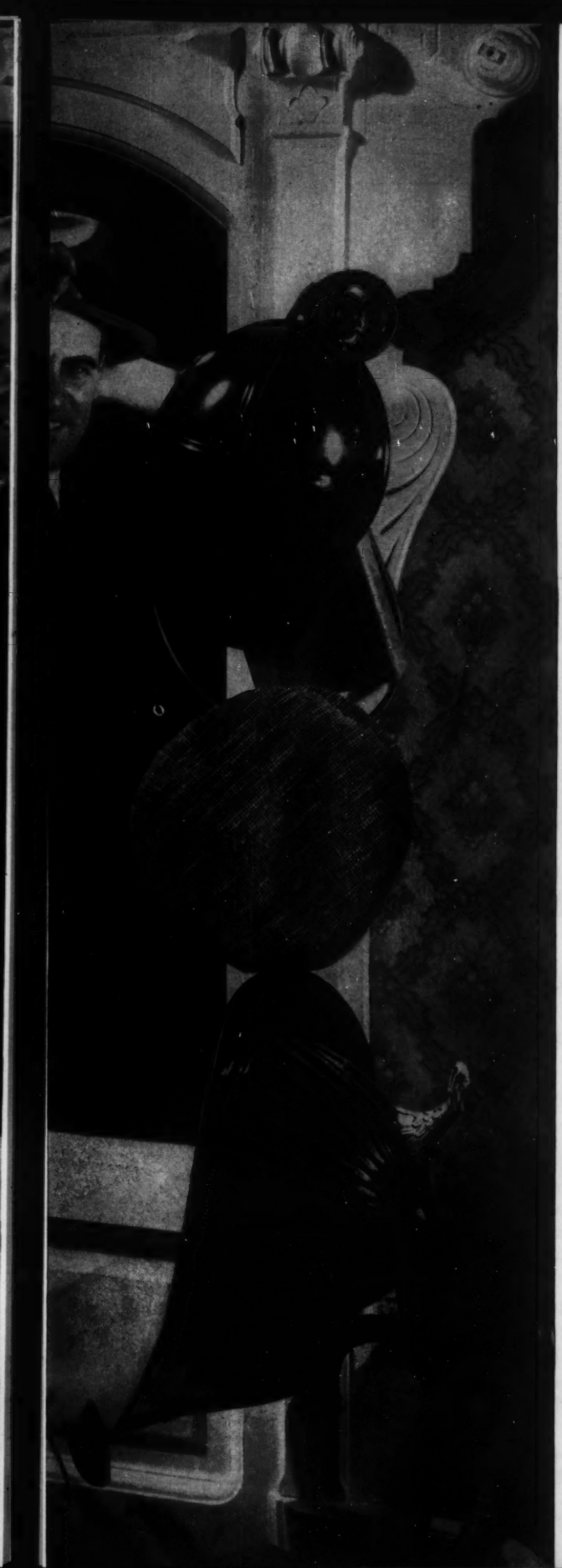
MODERN POWER FOR MODERN-DAY PRODUCTS

REULAND MOTORS

REULAND ELECTRIC COMPANY
WESTERN DIVISION: Alhambra, California
EASTERN DIVISION: Howell, Michigan
DISTRIBUTORS IN ALL PRINCIPAL CITIES

Circle 476 on page 19

*Trademark Registered



How many hats do you wear?

IT HAS BEEN SAID that a product design engineer must wear many different hats. First of all, he has to think out a gadget that will do a certain job without falling apart. Then, he has to be a production expert because he has to be sure that his gadget can be *made*. Can it be made economically? He has to know some cost accounting. Has he specified screwball component parts? He has to know a lot about purchasing—what materials are available, when they can be delivered and all the rest.

Since most machines contain some springs, your design engineer should (ideally) also be a spring engineer. But don't you have to draw the line somewhere? The most skilled group of spring engineers in the nation are at your beck and call without any obligation. The men at American Steel & Wire have been specialists all their lives. A problem that is new to you may be old hat to them. More than that, they know spring-making *machinery*, and can suggest design modifications that will allow more efficient production methods. Result? Lower cost for you.

Like they say in the ads, no order is too small or too large. Just call your AS&W representative.

AMERICAN STEEL & WIRE DIVISION
UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO,
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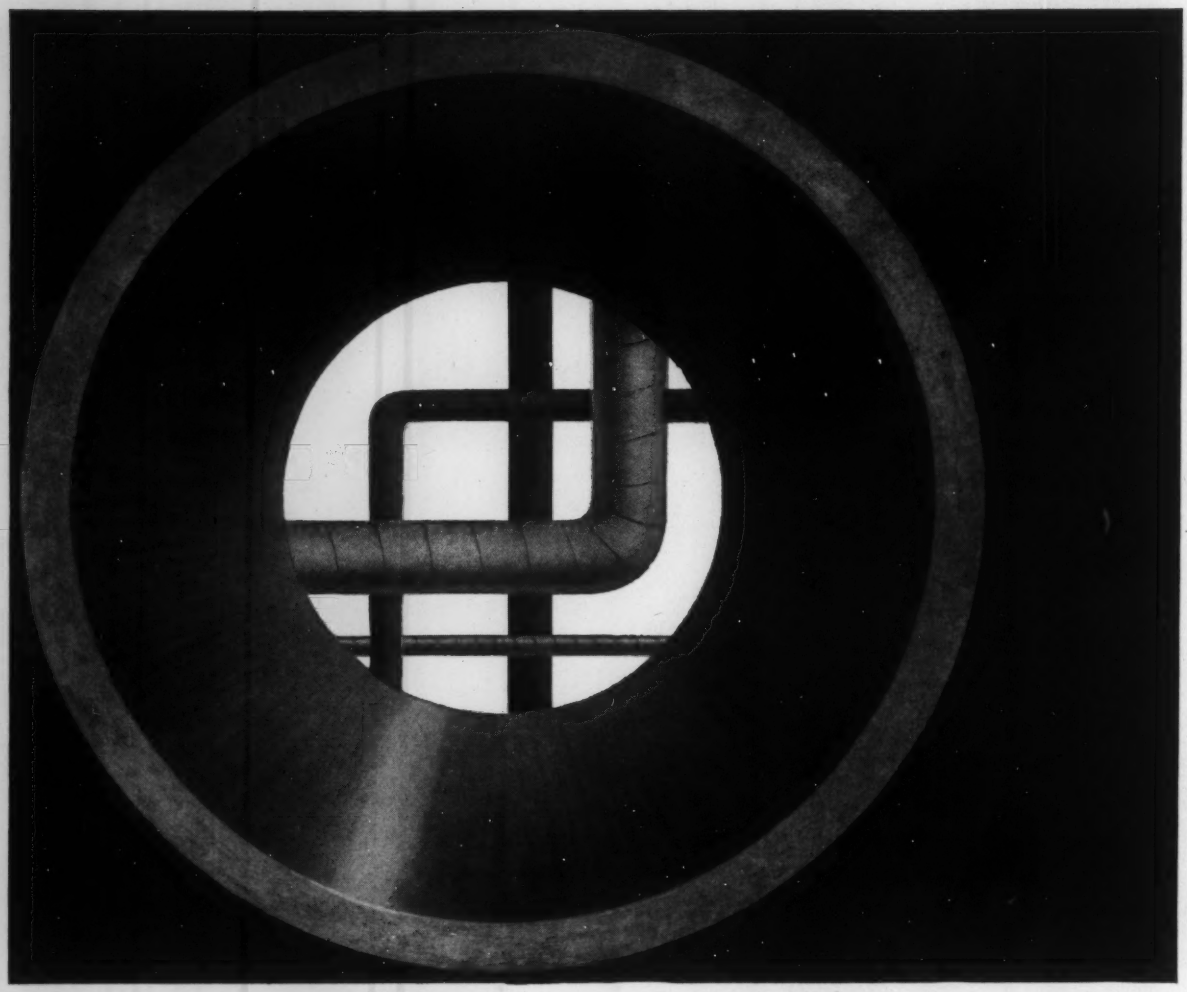
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN *QUALITY* SPRINGS

UNITED STATES STEEL

USS

Circle 477 on page 19



Enjay Butyl—*today's super-rubber*

improves pipeline protection...cuts costs!

Plicoflex® Tape Coating, revolutionary new pipeline wrapping developed by Plicoflex, Inc., combines the outstanding protective properties of Enjay Butyl Rubber with the identification properties of a color-bearing plastic film to which the Butyl is laminated. Applied over an Enjay Butyl based primer and forming a permanent bond to the metal, the tape features: absolutely *no* moisture migration or penetration; exceptional resistance to shock-impact; excellent dielectric properties, and outstanding resistance to normal and unusual corrosive influences. This *cold-applied* wrapping is *safer* and *cheaper* to apply by hand or machine than hot coatings and requires fewer personnel.

This is still another in the steadily growing number of products developed with Enjay Butyl Rubber. Contact the Enjay Company for complete information about this truly *wonder* rubber . . . where it can help *you!* Complete laboratory facilities, fully staffed by trained technicians, are at your service.

ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY

Pioneer in Petrochemicals

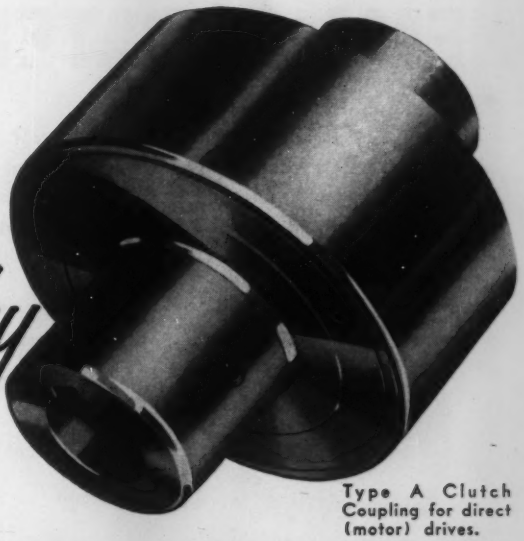
ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

Circle 478 on page 19

3 Reasons why

1. FULL LINE of clutches and clutch couplings for any type of power drive.
2. MANY YEARS of power transmission specialization in design, engineering and manufacturing.
3. ENVIABLE RECORD on maintenance service, new parts, correct installations.



Type A Clutch Coupling for direct (motor) drives.

CENTRICS are right for any Power Drive

The Trig-O-Matic Overload Release Clutch.

. . . Centric Clutches or Clutch Couplings

Regardless of type of drive or capacity, whether for motor, dual, engine or indirect drives, there's a Centric Clutch or Clutch-Coupling from zero to 2500 H.P. to meet the need. And if overload is your problem, the Centric Trig-O-Matic Overload Release Clutch can be your remedy.

What are your drive problems?

Just tell us the type of drive, capacity and any other pertinent details and we will send you the bulletin on the correct clutch or clutch-coupling best suited to your needs. There is no obligation.

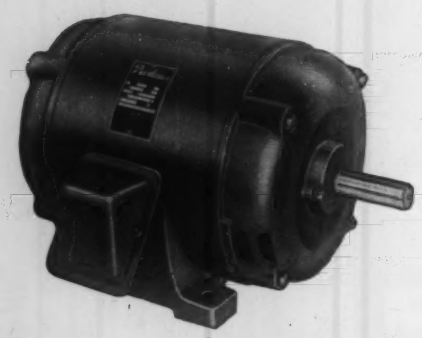
CENTRIC *Clutch Company*

P. O. BOX 175 • U. S. ROUTE 9 AT MAIN STREET • WOODBRIDGE, N. J.

Circle 479 on page 19

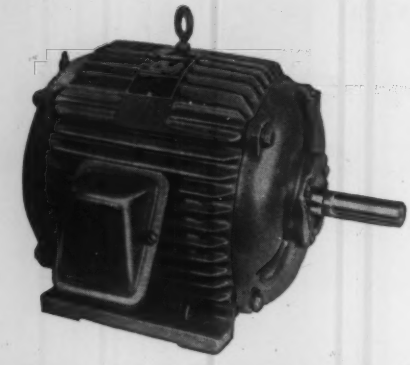
NEMA RERATED FRAME DESIGNS

Let Peerless engineers show you how these new frame designs can be modified to meet your mounting or other problems. They will show you how you can preserve, in production, the efficiency you put into your machine in design. See your nearby representative today or write direct. There's just one motor that will power your product best. Peerless will work with you to design and build it.



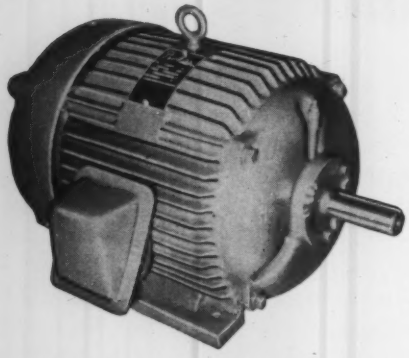
DRIP-PROOF (Open Type)

Frame sizes from 56 thru 326. Cast-iron construction. Furnished with ball or sleeve bearings. All exterior surfaces are smooth and symmetrical. Streamlined design affords complete protection against dripping liquids or falling particles.



TOTALLY ENCLOSED NON-VENTILATED

Totally enclosed, non-ventilated, from 1/2 to 3 HP. Recommended for use in non-explosive abrasive dust, metal dust, or where foreign matter may enter a motor. Positive protection of motor windings. Same design used with larger motors that drive propeller-type fans where the fan blows cooling air directly over the motor.



TOTALLY ENCLOSED FAN-COOLED

Totally enclosed, fan-cooled, from 1/2 to 30 HP. Cooling air is drawn by an external fan across the motor towards the driven machine. Heat generated by the machine is not drawn across the motor. Same system used in standard, fan-cooled motors and explosion-proof designs.

ELECTRIC MOTOR DIVISION

THE *Peerless Electric*® COMPANY

FANS · BLOWERS · MOTORS · ELECTRONIC EQUIPMENT

1520 W. MARKET ST. · WARREN, OHIO

Circle 480 on page 19

WEBSTER'S NEW PILOT OPERATED RELIEF VALVE

Compact design adapts to "tight" installations. Adjustable from 500 to 2000 psi. Maximum capacity, 20 gpm.

BOOSTS WORK OUTPUT 38.5%!

call the man from Webster

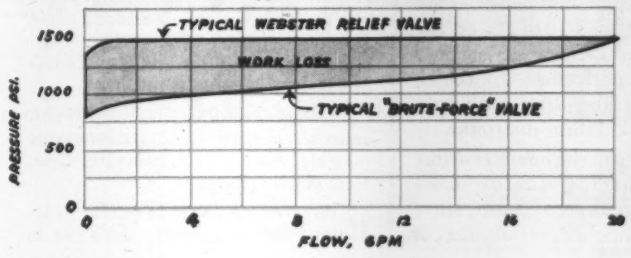
His intimate knowledge of this new relief valve — its many benefits and applications — can help in adapting it to your product.

Full speed power up to 93% of relief setting is now possible with this new Webster pilot operated relief valve. Result: 38.5% work bonus over "brute-force" type valves! More, you get all the benefits of clog-free performance, quieter operation...lower price. Mighty sound reasons for specifying Webster's pilot operated relief valve *now*.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC
MELROSE 3-3511
RACINE · WIS

Typical performance curve shows minimum pressure drop and instantaneous response of Webster pilot operated relief valve over "brute-force" type. 38.5% work bonus!



- ☐ *Have THE MAN FROM WEBSTER contact us—*
- *—Please send the following:*
- ☐ *Bulletin H3A2 covering the new Webster pilot operated relief valve*
- ☐ *Complete hydraulic catalog of pumps, valves and fluid motors*
- ☐ *New information or data as published*

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Company_____

City_____ State_____

franklin adv. H104

Circle 481 on page 19

Use of Recordak 35mm Microfilm in Filmsort aperture cards brings new efficiency to your drafting room

NEW RECORDAK PRECISION ENGINEERING DRAWING SYSTEM

Destined to change drafting room procedures the world over!

Important Recordak discoveries in 35mm microfilming techniques and quality control greatly increase the scope of aperture cards. Simplify filing, reference, printmaking, and distribution in drafting rooms large and small.

Now, *for the first time*, engineering drawings, prints, specification sheets—all sizes, all ages, all colors—can be reproduced uniformly, without loss of detail, *on low-cost 35mm microfilm.*

Picture, if you will, a faded blueprint with white lines; a soiled tracing with gray lines; a mottled brown Van Dyke with yellowed lines; a spirit duplicator copy with purplish images: From this assortment of negatives and positives you get white on black *negative* 35mm copies—with needle-sharp line detail and amazingly uniform backgrounds. (Background densities are controlled within 2/10 of 1% on the A.S.A. neutral density scale.) And this magic is performed—not with 70 or 105mm film—but with low-cost Recordak 35mm microfilm.

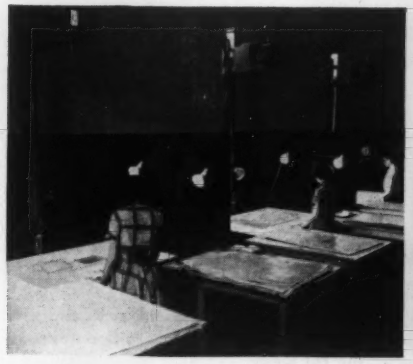
The next step in the new Recordak System—putting one or more frames of these superb 35mm reproductions in punched, tabulating, or other standard cards—gives you an active drawing file which saves engineering time, steps up efficiency.

How Recordak System cuts costs

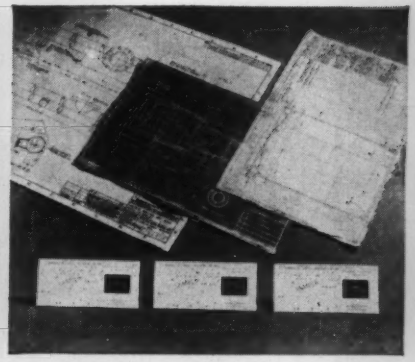
☐ ***Decks of cards replace acres of files.*** Now you can keep thousands of drawings at your fingertips in uniform trays. Save as much as 95% of floor space and cabinets now required for inactive or superseded drawings.

☐ ***Drawings can be filed according to sequence number***—impractical or impossible before when drawing size varied from small to large.

☐ ***Reference is faster.*** Your Recordak 35mm Filmsort aperture cards can be



Recent Recordak improvements in 35mm microfilming techniques and quality control make new system possible



Drawings and prints of all ages, sizes and colors are reproduced uniformly on Recordak 35mm Microfilm

Decks of cards replace acres of files—thousands of microfilmed drawings can be kept at the fingertips

checked immediately in a specially designed film reader, next to your drafting board.

☐ ***You get prints faster.*** Having aperture cards at your fingertips also pays off whenever prints are needed. Enlargement prints are made directly from the cards in seconds using photographic or electrostatic methods.

☐ ***Lowers distribution costs.*** Pays to ship Recordak Filmsort aperture cards —instead of blueprints—to branches, repair depots, subcontractors. They enjoy the advantages cited above. You speed distribution, slash mailing costs.

☐ ***Gives you low-cost protection*** Duplicate film copies can be made from the master film or aperture cards and vault-stored at low cost. An impossibility with bulky drawings.

Improves print quality

The quality of the Recordak 35mm film images is so exceptional that enlargement prints made from them will be as readable as the originals. You are invited to compare their quality with prints you are now getting from your original tracings or intermediates of any type.

Fills urgent need

In large companies and government agencies the problem of storing, distributing and protecting engineering drawing files is, of course, more acute than in the smaller ones.

In these large organizations, further economies can be realized by correlating the use of Recordak Filmsort aperture cards with mechanized filing, sorting, duplicating and enlarging systems.

New system hailed by engineers and draftsmen

Already many well-known companies have launched programs employing Recordak's new system. You are cordially invited to make any comparison, to make any test. No obligation whatsoever.

Free booklet gives full details

Must reading for every engineer and draftsman . . . explains the new Recordak System in detail. Shows how you can bring its advantages to your drafting room using your own Recordak equipment and following Recordak procedures. Or by calling on Recordak's Technical Service Department to do the complete job.

Reference is faster—any microfilmed drawing can be checked immediately in a specially designed reader

Enlarged paper prints can be made in seconds directly from aperture cards

"Recordak" is a trademark

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415 Madison Avenue, New York City

Gentlemen: Send free booklet describing new Recordak Engineering Drawing System. No obligation whatsoever. 19-10

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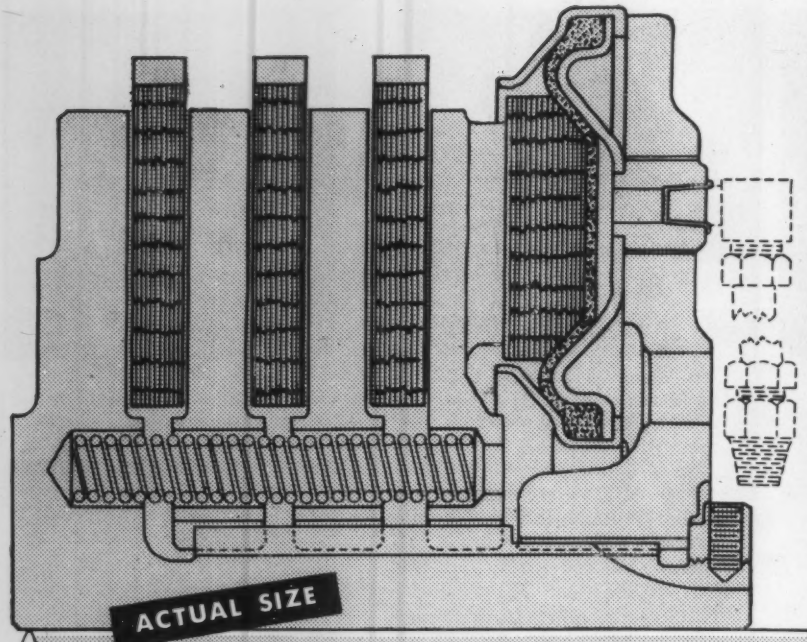
RECORDAK

(Subsidiary of Eastman Kodak Company)

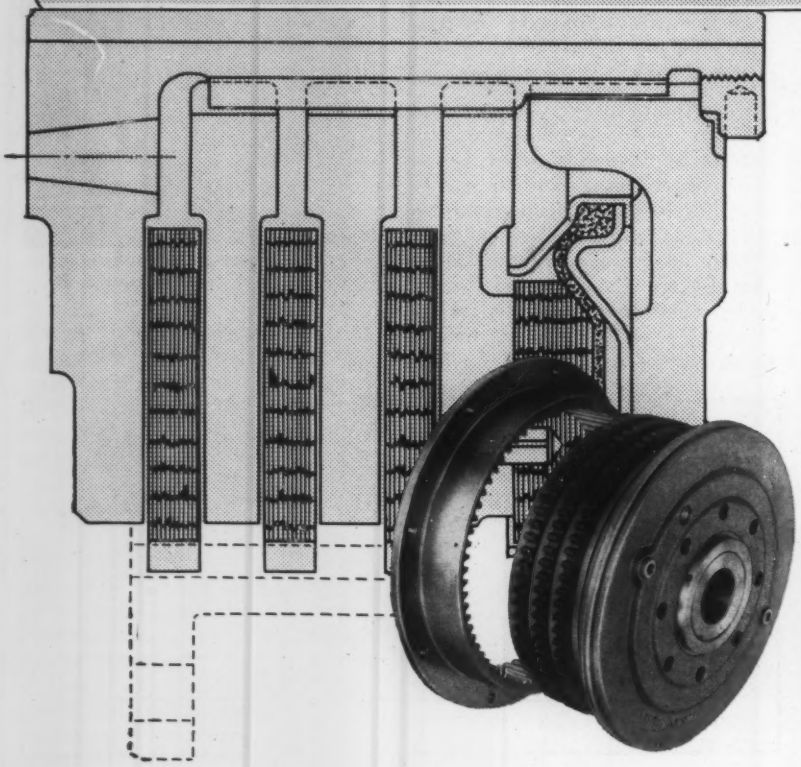
originator of modern microfilming— now in its 30th year

Circle 482 on page 19



- New design permits highest capacity at up to 40% less cost than comparable remote controlled air clutches!
- Available in sizes 8, 10 and 11½ inches . . . in triple-plate, double-plate and single-plate construction . . . with maximum torque capacity of 3503 pound-feet.
- Exclusive cartridge-type diaphragm of long-lasting neoprene reinforced with nylon . . . eliminates leakage and provides long life.
- Provides constant torque capacity without adjustment . . . self-compensating for wear.
- Compact and rugged . . . with clutch mass properly distributed relative to friction area, providing long life on high energy loads.
- Narrow width permits replacement of old-style drum or band clutches.
- Suitable for air systems up to 130 pounds per square inch.

New LOW COST high capacity Twin Disc Air Clutches



The new Twin Disc 8, 10 and 11½-inch PO Air Clutches are adaptable wherever the convenience of remote air control is desired. They are currently in use on rock crushers, tractor winches, pipe-extruding machines, drilling rigs, machine tools, pug mills and other equipment.

The three new sizes extend the time-tested, job-proved line of PO Air Clutches from 8 to 36 inches in diameter . . . in torque capacities to 126,600 pound-feet.

Check your next design . . . see for yourself how PO Air Clutches lend themselves to convenient, economical remote control. Write Twin Disc Clutch Company, Racine, Wisconsin.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC

Friction Clutches and Fluid Drives

Circle 483 on page 19

DESIGN
October 17, 1957

Management's Responsibility

IF you apply for admission to a school of business administration you may be asked such questions as, "What is the purpose of a foundry?" If you answer, "To make castings," you flunk.

A man with good management potential knows, of course, that the purpose of a foundry is to make money.

First reaction to such a seemingly hard-boiled attitude might be, "How greedy can you get?" But sober reflection leads to the conclusion that the man is right.

Money is the yardstick by which much that we value is measured. And so long as we don't fall in love with the yardstick instead of with what is being measured, we can keep the concept of money in proper perspective.

The output of a foundry in tons of castings tells us little about its contribution to human progress. But sales dollars and profit give a measure we can recognize and interpret in terms of benefits to owners and employees.

Boss Kettering goes a step further and speaks of the double profit system. In his view the customer should profit equally with the seller from any business transaction. Any other system is no better than a racket.

An engineer is called upon to apply his thoughts and energies to ideas and things, rather than to people and money which are the province of management. His experience therefore has conditioned him to look upon a foundry primarily as a place where things are made—and an engineering department as a place where ideas are translated into things.

It should never be forgotten that even the most benevolent and altruistic management—in foundries and everywhere else—is solidly dedicated and committed to making money. The most successful managements are the ones that make the most money for the most people.

An engineer's value to his company, of course, is proportional to his alignment with that viewpoint. So is his effectiveness as a professional serving the public.

Colin Carmichael

EDITOR

RESEARCH FOR RESULTS

By **PHILIP R. MARVIN**
Manager, Research and Development Div.,
American Management Association
New York

Industrial Research

What is the role of research in contributing to company growth? This question is best answered by considering six basic points:

1. **What are the objectives of research?**
2. **Should research produce profits?**
3. **How much should be spent on research?**
4. **What makes a good research project?**
5. **What makes a good research director?**
6. **How is research organized?**

These questions are answered in this article, fifth in a current program on profitable new-product development programs.

MISUNDERSTANDING of the research function probably accounts for more dollars lost during product development than by any other single factor. Frequently it is not understood what is really meant by research or how to use research in an effective manner. Millions of dollars are spent every year on research but only a fraction of these funds result in worthwhile output.

Managements of too many companies have been enamored by large research appropriations rather than by the need for a penetrating analysis of research operations. Research is not product development. In recent years, research departments in many companies have become sidetracked by product-development assignments. Partly this has been the result of management decree. In other instances it reflects empire building. A more serious cause has been the rejection of engineering responsibilities by the engineers themselves.

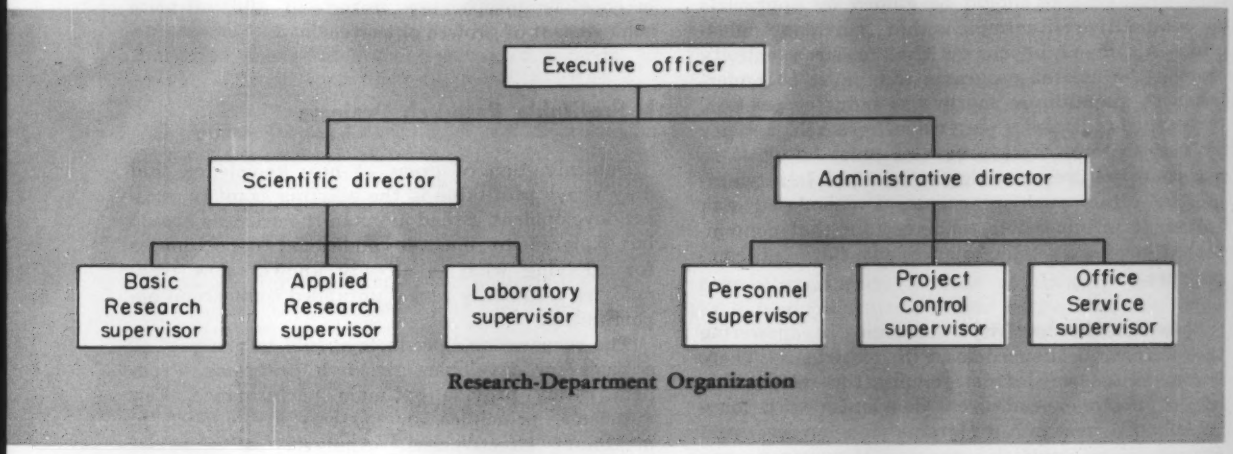
As an immediate consequence of this increase in the scope of research activities, essential research programs have been pushed aside in favor of more immediate production problems. Research staffs are usually competent in handling a wide range of assignments that could and should be done by others. This competence has proved costly where it resulted in diversion of research talent on assignments of a nontechnical nature.

Effective research administration calls for an understanding of this vitally important phase of business activity. A complete understanding comes only through experience resulting from actual administration of research programs. Practical experience is made much more profitable when time is set aside for review and analysis of the administrative process of research management.

Research Objectives

Research points the way to new business opportunities—new products, processes, and lowered costs. Once these opportunities are revealed, engineers should take over the job of developing the most promising projects. This leaves the research group free for further exploratory studies. If this policy is not followed, the exploratory studies stop because there is no time for them. New ideas cease to flow and stagnation sets in.

New technology and accumulated scientific knowledge must be scrutinized constantly in an atmosphere of changing needs to find new and potentially useable product concepts. At the same time, new skills and techniques must be developed as needed to enlarge the scope and effectiveness of the research process. Research continually "freshens" product thinking and stimulates product-development activities. It provides new concepts, principles, and technical supporting data.



Research-Department Organization

These fruits of research form the basis for product development.

Profits from Research

Difficulty will always be encountered in making every research program pay off. An attempt to do so would seriously cripple research efforts. From a practical business position, however, projects must be reviewed periodically and those projects terminated that are not obviously heading in directions of significance to the corporation.

Some businessmen—and some scientists, too—have stated that research never results in losses. This is sheer nonsense. While improperly administered research programs may result in new knowledge, unless it represents useful knowledge it will not produce new income. Shareholders look for increased equity and dividends. Soundly administered research makes a major contribution and is a profitable investment.

There is something radically wrong with research programs that do not lead to new income. Failure to produce returns reflects on the research manager. Research is a basic business function. It can be mismanaged like any other business activity with resulting losses to the corporation, or it can be effectively administered and produce profits obtainable in no other way.

Research Spending

Management must approve research appropriations—a difficult job. Any good research group can think up ways to spend money faster than it can be accumulated. This is a sign of healthy, active research thinking.

A research group should indicate areas that, in their carefully considered opinion, might prove profitable to the company. It is up to management to determine how much of the over-all program it is feasible to tackle. This decision must take into consideration available funds and management's growth objectives.

Judgment should replace reliance upon statistical percentages in grappling with this problem. The fact that research expenditures currently run to 6 per cent of sales in the aircraft industry provides very little actual guidance in establishing a research program. It does establish a level of activity that is a measure of competitive effort between or within industries. By contrast, current research expenditures in the paper industry are between 0.75 and 1 per cent of sales. Other indications of the level of activity are estimates of research and development expenditures. Total estimated research and development expenditures, divided according to individual industry groups, for the year 1957, are:

Aircraft	31 per cent
Chemicals & chemical products	13
Electrical equipment	18
Fabricated metal products	2
Machinery	8
Instruments	4
Other	24
Total	100

Judgment in establishing research opportunities depends to a large degree on ability to answer four questions:

1. How much are competitors spending on research?
2. How is research productivity related to research appropriations?
3. How much would it cost to make effective use of research results?
4. How much can the corporation afford to appropriate for growth?

Competitor Activity: In answering the first ques-

tion, management should be guided by appraisals of competitive situations within individual industries. Appraisal of competitive research activity reveals the size of programs that must be undertaken to maintain or improve an industry position. If analysis discloses extensive research activity by competitors, these programs must be offset to maintain the present industry position. In attempting to offset such programs, a calculated risk arises. It is impossible to be certain that contemplated programs will balance out those of competitors.

Research Productivity: Accuracy in answering the second question comes with experience. There is no precise way of determining the relationship of output to expenditures. Companies with long-established research programs can project past experience to establish estimates. However, no two research programs have the same output. Research productivity depends on many factors. The selection of projects, the planning of investigational programs, and the staffing of these programs determine productivity. Multiple-project programs will allow performance averaging.

Cost of Using Research Results: Not only is it necessary to estimate the cost of productive research programs, but it is equally important to know how much it will cost to turn research results into commercially feasible projects. Timing is a cost factor too. Rarely can research results be tabled or shelved until resources are available for their application. Competition will not permit this. Research results that are put on the shelf are usually forfeited to competitors. Timing is related to management's sensitivity to new-product problems.

Some management groups will be faster to act than others. This, in part, reflects management's receptiveness to new ideas as well as its responsiveness to the added demands on executive time that necessarily accompany any new undertaking.

Size of Investment: Another part of the over-all picture is identified with the availability of funds for corporate expansion. There is always an upper limit to the amount of money that can be diverted from current income for investment in the future. An evaluation of the upper limit of funds that will be available in future years for research, and the commercial development of new products, provides a basis for establishing research budgets. These budgets must effectively be in balance with funds available for turning research results into products.

There is a practical limit to the size of research programs that corporations can undertake. Growth costs money. Competitive research activity and growth objectives indicate the magnitude of research programs that may be necessary. Follow-through to commercial products incorporating results of the research is part of the total cost of growth. Research is useless unless it results in profitable products. Commercial-development competence is inseparably linked to the ultimate achievement of growth objectives.

Profitable Research Projects

Determination of areas of new knowledge that may prove profitable is the starting point in project development. Broad areas in the sciences should be explored to uncover additional opportunities for applying what is already known. New technologies frequently reveal untapped commercial opportunities.

The corporation's products should be analyzed as a basis for developing research programs. Products rarely provide optimum performance. Few materials, principles, or systems are applied at maximum effectiveness. Analysis of consumer needs discloses subjects for research investigations.

In analyzing products four questions are pertinent:

1. In what ways do specific products fall short of the consumer's ideal?
2. What manufacturing limitations prevent production of this ideal product?
3. What technical limits are imposed upon laboratory models of the ideal product?
4. What theoretical limits exist?

Answers to each of these questions reveal areas where new knowledge can be put to good use by the corporation.

Before any research is attempted to develop new knowledge, an effort should be made to locate the answers to pertinent questions on the basis of existing knowledge. A survey should be conducted to isolate studies underway by other research groups that might result in pertinent information for the problem at hand.

If these possibilities fail, a need for research is indicated. Priorities for potentially profitable programs are established by evaluating the probable outcome of research, program costs, and projected returns.

Organization of Research Programs

Discussions of organization structure have the common fault of being either so specific that they are useless or so general that they are equally useless. Both result from failure to focus attention on functional interrelationships essential to the accomplishment of organizational objectives.

Accomplishment of objectives requires that certain functions be performed. Relatively clear-cut relationships between objectives and functions begin to cloud up as soon as the staffing process commences.

Rarely, if ever, can individuals be found who are tailored to the job. Compromise is used as the best men available are selected. Jobs are tailored to the knowledge, judgment, experience, and innate capacity of the men chosen. It is impossible to know the full impact of the men on the job.

Yet, without this knowledge, the usefulness of an existing organization can not be appraised. This limitation necessitates the creation of a model to provide a framework for reference.

A Model Organization: Such an organization serves as a starting point to establish a new research group and provides a basis for auditing the operations of existing research programs. If research is to be effective, those engaged in research pursuits must be freed from administrative details. Implementing this concept is the starting point in the development of the research organization.

The Two Key Functions: The successful research organization is built around the functions of the administrative director and the scientific director. In smaller research groups, one man may assume both roles.

Few companies will be fortunate enough to find individuals who are competent scientists as well as capable administrators. It is more probable that in the smaller company it will be necessary to make a compromise between a good scientist and a poor administrator on the one hand and a capable administrator on the other. Where compromise is necessitated by scale of operations, the better scientist should be chosen. Without the competent scientist there can be no research. As the organization grows in size over the years, administrative talent can be added. Programs capable of supporting larger organizations can take advantage of the added operating effectiveness resulting from a separation of administrative and scientific functions.

The Administrative Function

The administrative director's role fits a relatively familiar pattern. He is responsible for business relationships in the research organization. His activities can be broken down into three general areas of supervisory responsibility. He is responsible for planning, organizing, and controlling research activities. In carrying out these responsibilities, the administrative director may require the assistance of a project-control supervisor, a personnel supervisor, and an office-service supervisor.

The Project-Control Supervisor is responsible for the development of work schedules for new programs to be undertaken. It is also his responsibility to relate actual performance to established schedules once programs are underway.

New programs must be broken down into manpower and facilities requirements and compared with available supplies of each resource. Based on this analysis, time schedules can be established that are compatible with the men, money, and physical tools available for the project.

The project-control supervisor must rely on the advice of those who actually execute programs for the information that goes into making up schedules. He should not attempt to act as an expert in any area of technical specialization. The project-control supervisor takes facts as they are presented to him and shapes these facts into completely objective and realistic programs in terms of dollars and time.

The second major responsibility of the project-control supervisor is that of revising schedules as individual projects either lead or lag the original estimates. Schedules should always present up-to-the-minute projections of the latest probable course of the development of projects underway. Once project schedules are initially established, management should no longer need to concern itself with a review of these schedules. It should be sufficient to review periodic reports issued by the project-control supervisor detailing changes in these original schedules. These changes point up areas requiring further administrative attention. Revised schedules reveal to the research executive the degree to which corporate objectives are being achieved in accordance with established management expectations.

The Personnel Supervisor is responsible for recruitment and placement of all personnel in the research organization. Final selection of candidates for positions is made by individual supervisors responsible for the area of operations to which new personnel are assigned. The personnel supervisor insures that sources of competent research personnel are tapped. Prospective candidates for positions are screened so that only those individuals reflecting the greatest potential value are referred to key members for consideration. Once new members of the research organization are selected and report for work, the personnel supervisor conducts indoctrination programs.

The personnel supervisor is responsible for the establishment of essential personnel functions in the research organization. This includes responsibility for programs designed to develop professional abilities and capacities.

The Office-Service Supervisor has broad responsibilities. Maintenance of the physical plant, management of nontechnical facilities and supplies and services fall within the scope of his activities. Provision of a secretarial staff, report-preparation facilities, record maintenance, library services, and related functions essential to the smooth working of a research organization are also his responsibility.

The over-all philosophy of the administrative director's role is that of absorbing all functions which are not so inseparably tied to the work of the research investigator as to make their separation impractical. By so doing, the research worker's time can be concentrated on the scientific phases of programs to be accomplished. This not only places administrative matters in competent

hands but, at the same time, reduces the diversion of both scarce and valuable research manpower.

To achieve optimum output from research programs, separation of administrative and scientific activities is essential. This organizational practice reflects a pronounced trend in current practices in administering technical programs.

The Scientific Function

The scientific director is responsible for the effective execution of all technical phases of a research program. He is responsible for the development and acquisition of technical personnel and tools necessary to implement these programs. Quality and quantity summarize his area of responsibility.

Objectives and specific program areas are established by the executive officer that is in charge of research. This is done with the approval of other members of the top-management group. In the establishment of these programs, the scientific director should play a particularly important role. The scientific director, as senior scientist closely associated with the individual research programs, is in a position to be particularly perceptive to significant developments.

Worthwhile new ideas and concepts are revealed by the work of the research investigator closest to the problem being studied. Unless channels of communication are maintained so that this thinking can flow upward, research programs will be relatively unproductive.

Once ideas have been generated and programs approved, it is the scientific director's primary responsibility to apply the latest knowledge, skills, and facilities in implementing these programs. The scientific function can be further subdivided into areas of responsibility assigned to the applied-research supervisor, the basic-research supervisor, and the laboratory supervisor.

The Applied-Research Supervisor is responsible for the execution of programs which relate directly to the company's products—those in the catalog and those planned for the immediate future. Applied research is product-oriented. There is no particularly distinguishing feature to differentiate between applied research and basic research other than the fact that applied research is influenced to a very large degree by specific product requirements. This in itself is sufficient to justify separation of applied-research activities from those in the area of basic research.

The Basic-Research Supervisor is responsible for programs with the objective of revealing opportunities for new products. Effective basic research requires a certain freedom from day-to-day product responsibilities. This can best be achieved by a distinct functional separation. The element of urgency which frequently attaches itself to applied research may cause these programs to encroach on basic-research investigations when this division in over-all responsibility is not made.

The Laboratory Supervisor is responsible for the development of skills and facilities essential in aiding the research investigator. Many of today's scientific tools require highly skilled operators and special laboratory facilities. Newer tools can be expected to accentuate this trend. The laboratory supervisor should co-operate with the individual scientists comprising the research group in determining requirements for purchasing scientific apparatus. Every effort should be made to anticipate future needs in order that new equipment acquisitions are functioning before needed by the investigator. Installations frequently involve lengthy training periods which must be completed before any reliability can be attached to the data obtained from a particular piece of apparatus.

The laboratory supervisor is responsible for the development of special equipment required by the research investigator. The objective is to free the scientist from the performance of any tasks which do not make an essential contribution to his work.

The Research Director

No individual who actually attempts to direct research makes a good research director. Experienced research executives recognize this. Industrial research is essentially a process of channelling creative thinking into potentially useful and profitable directions. In achieving results that re-

The function of Industrial Research

is to develop new knowledge and understanding . . .

To insure that the corporation will continue to operate in areas of growing business activity and profit potential.

To make best possible use of corporation resources such as raw materials, technical specialties and management talent.

To utilize available markets adequately.

To insure steadily increasing and stable profits.

To contribute to the corporation's ability to accept social and humanitarian responsibilities.

flect creative thinking, the research director must have the capacity to perform three major functions of great importance.

Selecting Creative Thinkers: A good research executive must have the ability to both pick and develop creative thinkers. Everyone has some creative ability but competition demands that the research group comprise the most creative minds available. Past performance is the best criterion of an individual's creative ability, but not the only one. However, other criteria are subtle and uncertain. The research executive must match his resources against those of his counterparts in other companies in picking creative people. Without them there can be no research.

Establishing Working Conditions: He must establish a favorable environment for creative work. Policies, procedures, and facilities must be geared to the creative process. Facilities must be available to the research worker at a minimum of inconvenience on his part. Creative thinking flourishes best under conditions that allow freedom of action. These and other factors are important in establishing a favorable environment for creative efforts.

Directing Interest: The research director must stimulate interest in areas of activity that are potentially profitable to the company. This does not preclude the opportunity for independent investigations but it does assure that the major emphasis will lie in areas that appear to have the greatest potential use to the company that foots the bill.

▶ Role of the Research Executive

The research executive guides the corporation in the direction of full utilization of new-product opportunities as they appear. He does this by interpreting the results of research investigations significant to top management. He must see that funds are appropriated for research programs that are adequate for long-range development of the corporation's product programs.

The research executive is responsible for numerous activities.

1. Disclosure to management of new-product opportunities revealed by research investigations or suggested by scientific advances. These opportunities serve as a background for decision-making relative to feasibility, practicability, and marketability of new-product concepts.
2. Evaluation of areas of scientific endeavor to isolate opportunities for further work. Evaluation must also assess the potentials and limitations manifestly inherent in such areas.
3. Definition of fields of corporate interest and the stimulation of the recognition and formulation of problems in areas of company interest.
4. Selection of the most promising problems and the establishment of priorities based on the limitations imposed by time and budgets.
5. Assessment of research proposals in terms of manpower, methods, and facilities required.
6. Implementation of programs.
7. Development of needed technology as rapidly and as efficiently as possible.
8. Reassessment of problems during the course of solution with corresponding changes in methods, manpower, and facilities as work proceeds.
9. Abandonment of projects that are not productive or that should be displaced by more promising programs.
10. Co-operation with members of the management team in assisting the effective utilization of new technology.

In discharging these responsibilities, the research executive draws heavily on the resources of his two principal operating executives — the scientific director and the administrative director of the research organization. These men are individually responsible for specific areas of operations. The research executive must maintain a continuing evaluation of the effectiveness of these operations and at the same time develop plans to increase the over-all usefulness of these operations. In doing this, the research executive may make use of staff assistance for operations-research and technical-feasibility studies.

Operations Research

One of the major interests of the research executive should be that of research into the research process itself. Investigations of this type can best be handled by staff members in the office of the research director who specialize in operations-research studies.

Such investigations will analyze the more successful research projects, comparing them with less-successful programs in an effort to reveal significant operational differences in the handling of the two. The operations-research group should construct model organizations and operating procedures in an effort to optimize output from the manpower, money, and facilities devoted to research and development.

Operations research should be a continuing function. Changes are constantly occurring within the research organization and in the general corporate environment in which the research group operates. These create opportunities for more effective procedural relationships. Those charged with day-to-day responsibilities usually find it difficult to set time aside for studies designed to improve the efficiency of their own sphere of operations. It is even more difficult for these people to find time to study operations outside their own specific area in order to improve working relationships.

Freed from day-to-day commitments, operations-research specialists not only have the time to conduct such studies but also have the opportunity to acquire highly skilled techniques and facility for

such investigations. Operations-research reports are informative, interpretive, and advisory in nature. They provide the research executive with objective data as a basis for administrative action.

Technical-Feasibility Studies

Another aid to the executive administering the research organization is supplied by technical-feasibility studies. These studies suggest new directions for research, new approaches that can be applied in existing programs, areas in which technical skills should be developed, and new techniques which should be explored. Technical-feasibility studies provide data useful in evaluating technical programs and in formulating future plans.

The results of both operations research and technical-feasibility studies provide objective recommendations with supporting background data. They are stimulants to dynamic operations. Established as formal staff functions operating in the office of the research executive, or conducted less formally, operations research and technical-feasibility studies are basic analytical techniques in the administrative process.

▶ Capitalizing on Creativity

Industrial research is undertaken to capitalize on creative talent. It is a search for new knowledge resulting from a better understanding of phenomena, materials, and the arts. Productive research reflects an understanding of the research function and the capacity to apply sound management principles in administering programs with the objective of capitalizing on creative talent. Effective research calls for channelling creative thinking into potentially useful and profitable directions. Research that does not pay off has no place in the corporation budget.

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This article is the fifth in a co-ordinated group by Dr. Marvin on new-product development. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

"Planning Product Strategy" ..... June 13, 1957
"Developing Ideas for New-Product Programs" ..... July 11, 1957
"Profitable Fields for New-Product Development" .. August 8, 1957
"Screening and Appraising New-Product Ideas" .. September 5, 1957

Tips and Techniques

Handling Whiteprint Paper

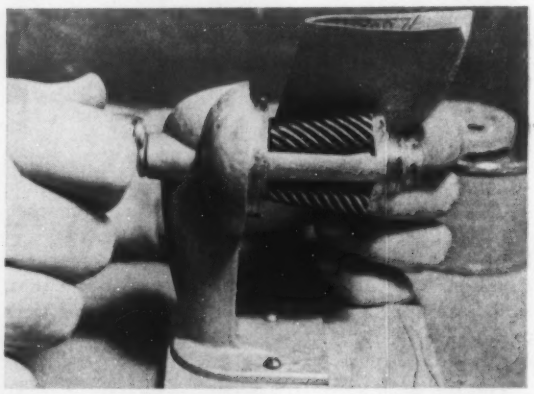
Various sizes of unexposed whiteprint paper may be stored in standard tracing file drawers to protect the paper from light and still make it easy to obtain a few sheets without wrinkling or mussing up the remaining sheets.

One drawer, 43 x 32 x 2 in., can hold 250 to 300 sheets of each of the following sizes of paper: 8½ x 11, 8½ x 13, 11 x 17 and 17 x 22. A box of either cardboard or metal is made to fit each of the different sizes of paper. The top of each box is cut along the front and part of the way along the sides to form a flap. When the operator wishes to make a print, it is only necessary to pull out the drawer, lift the flap of the box, take out the required number of sheets, and close the drawer.

This is more efficient than trying to get a few sheets out of a package, folding up the ends of the package (and possibly some of the protruding sheets), and putting it away.—W. H. BURNETT, *Hogan Laboratories Inc., New York.*

Reconditioning Pencil Sharpener

It is a fairly simple matter to sharpen a crank-type pencil sharpener to restore its original efficiency. Simply remove the outer housing and hold a piece of sandpaper or abrasive cloth against the spiral cutters. Turning the crank handle in reverse will restore the keen edge on the cutters.



A few drops of cutting oil or kerosene on the sandpaper speeds the job and produces a smoother cutting edge. — GLEN F. STILLWELL, *Manhattan Beach, Calif.*

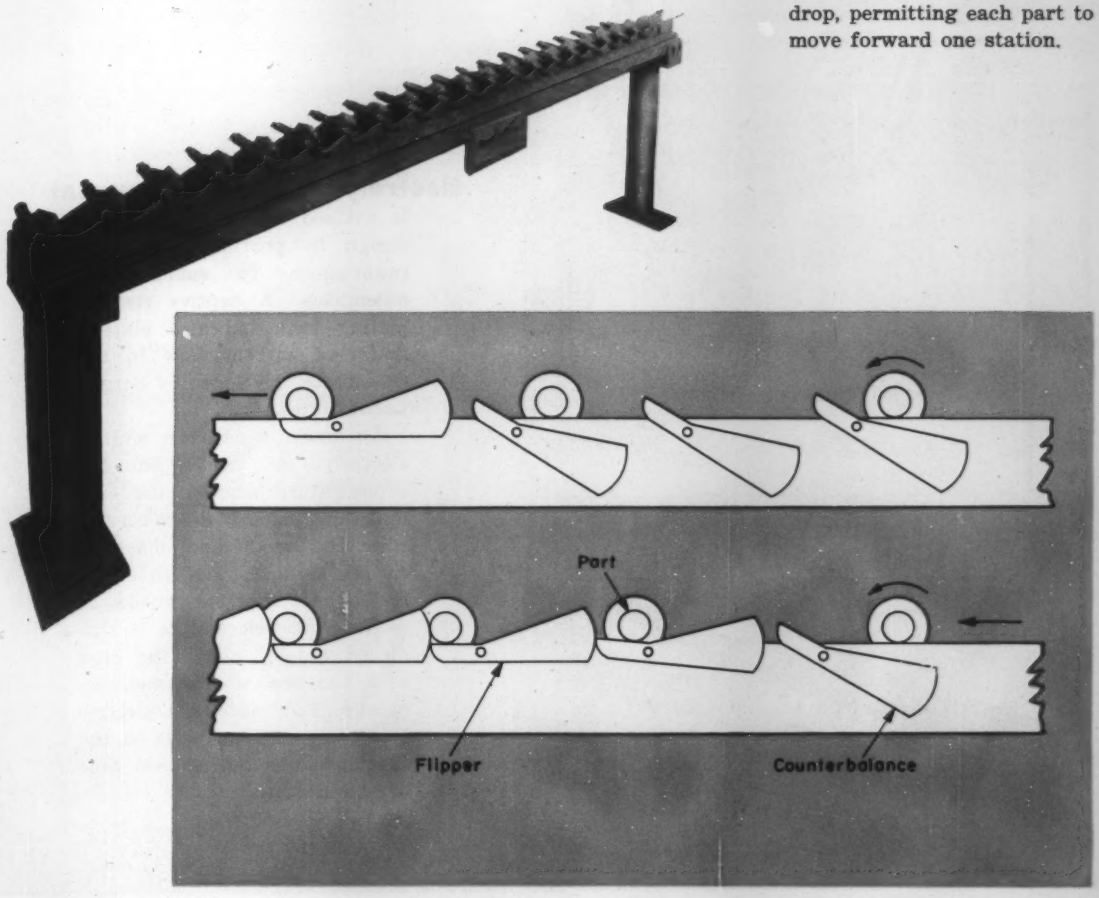
Scale Speeds Compass Setting

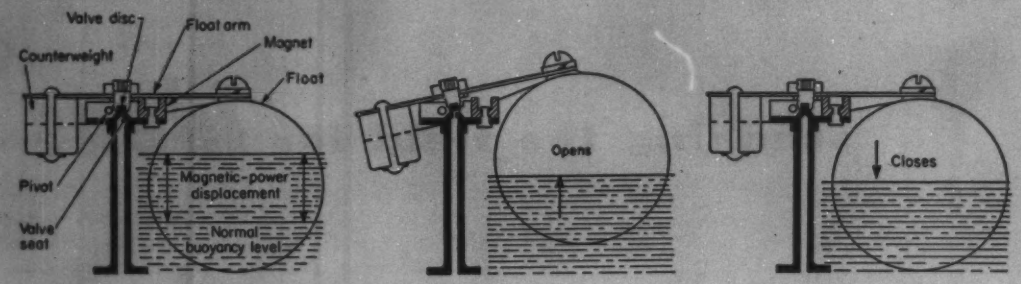
A 6-in. steel machinist's scale, taped to the straightedge, is very convenient for setting compasses or dividers. The graduations are etched or stamped into the metal and do not suffer from use of divider points as do plastic scales. Machinist's scales are available in a wide range of markings, with both decimal and fractional divisions.—ROY ANDREWS, *Tyler, Texas*

scanning the field for *ideas*

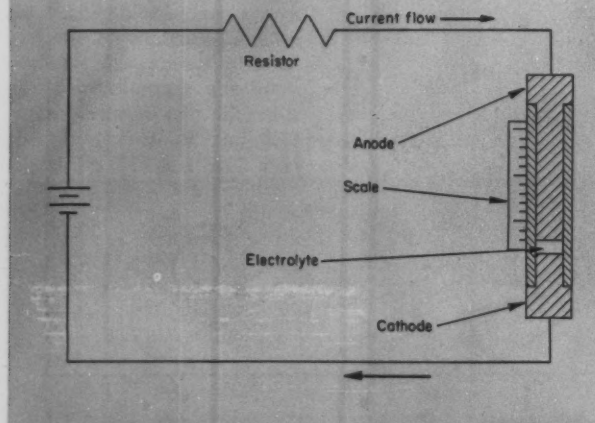
Automatic spacing of precision rolling parts moving in one direction of travel is accomplished by novel counterbalanced "flipper" members. In a gravity conveyor designed by Cargill Detroit Corp., a series of flippers is mounted on each side of the conveyor. Each flipper is pivoted so that the upstream, counterbalanced end hangs down when the flipper is not loaded, while the downstream end projects up into the path of moving parts.

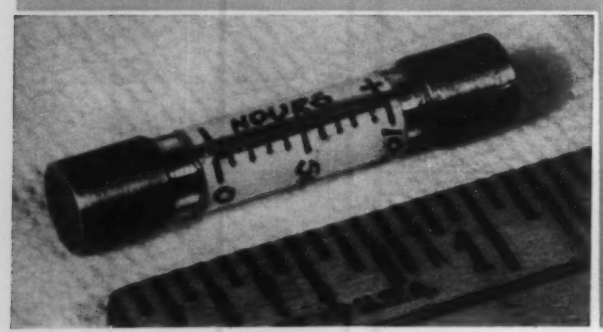
As a rolling part passes the flipper, it depresses the downstream end, raising the counterbalance up into the path of oncoming parts. If a part is left on the first flipper, its counterbalance stops the next part. Each succeeding part is stopped by the counterbalance ahead and actuates its own flipper to stop the following part. Removal of the first part from the conveyor allows its counterbalance to drop, permitting each part to move forward one station.





Magnetic snap-action linkage facilitates high-speed operation of float-type valve and assures positive opening and closing without chatter or "bounce." In the pilot valve of an air trap designed by Hankison Corp., a permanent magnet holds the valve shut until rising water level within the trap gives the float sufficient buoyancy to overcome the magnetic hold against the linkage and snap the valve open. Under falling water-level conditions, the magnet snaps the valve shut as soon as the water level is low enough to permit the attraction of the magnet to overcome the buoyancy of the float. The instantaneous action prevents air leakage through the valve seat and bouncing of the valve elements.

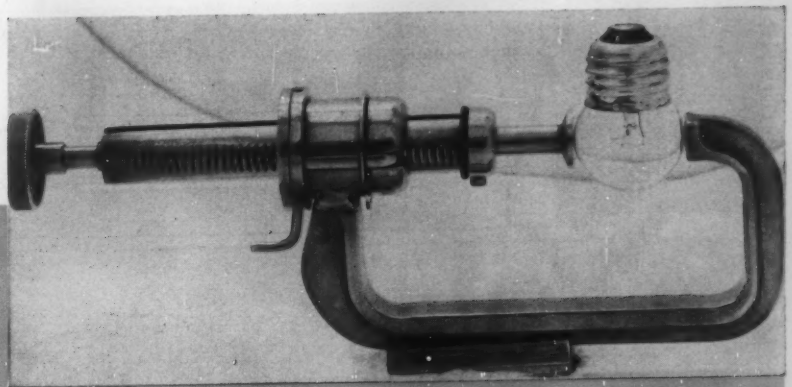


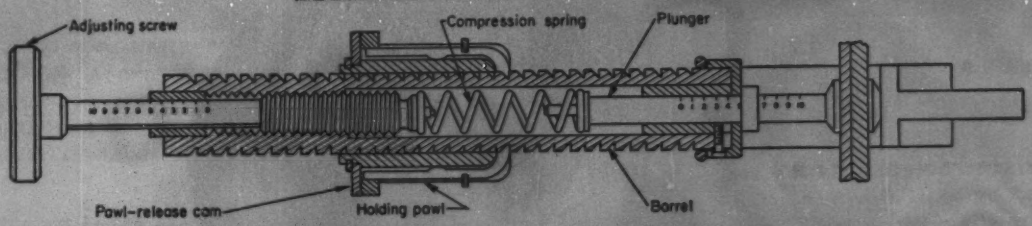


Electrolytic time measurement is utilized in a novel "clock" design to provide a compact instrument for subminiature assemblies. A captive electroplating bath indicates elapsed hours of current flow in the Chronistor, developed by Bergen Laboratories.

An anode, a cathode, and an electrolyte are sealed into the subminiature case. Under current flow, metal ions are carried from the anode and deposited on the cathode. Due to transfer of metal from anode to cathode, the electrolyte is displaced axially along the case as a function of time and amperage. Position of the electrolyte along an hour scale on the case indicates the elapsed time of current flow.

ideas

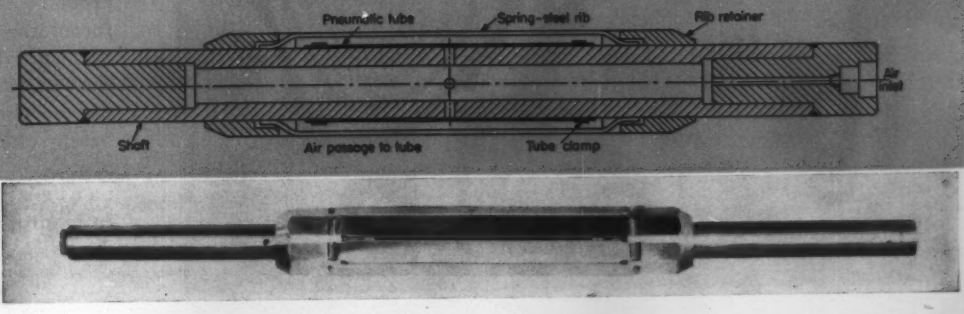




Adjustable clamping pressure is provided by a compression-spring assembly that permits precise control of spring preload to meet varying application requirements. A manual clamp design, patented by Dr. Clifford L. Hutson of Glendale, Calif., has a compression spring that bears against a clamping plunger on one end and an adjustment screw on the opposite end.

Clamping pressure is exerted by manually sliding a cylindrical barrel, containing the spring, adjustment screw, and plunger, until the spring-loaded plunger contacts the work. Slight additional movement permits ratchets to engage notches in the side of the barrel, holding the barrel in place and applying full spring-preload pressure to the work. Further movement of the barrel increases the spring compression and results in additional pressure. Release of clamping pressure is effected by backing off the adjustment screw or rotating a cam to release the pawls.

Expanding-shaft design develops positive internal clamping action for secure fastening of mating parts without conventional keys or set screws. Designed by Paper Converting Machine Co. to support and hold rolls of paper, the shaft construction consists of a metal tubular core, a neoprene tube surrounding the core, and a spring-steel rib cage. Compressed air introduced through the core and into the tube causes expansion of the tube and distention of the ribs, firmly engaging the bore of the mounted paper roll. The shaft maintains uniform holding action without slippage until a release valve permits deflation of the core.



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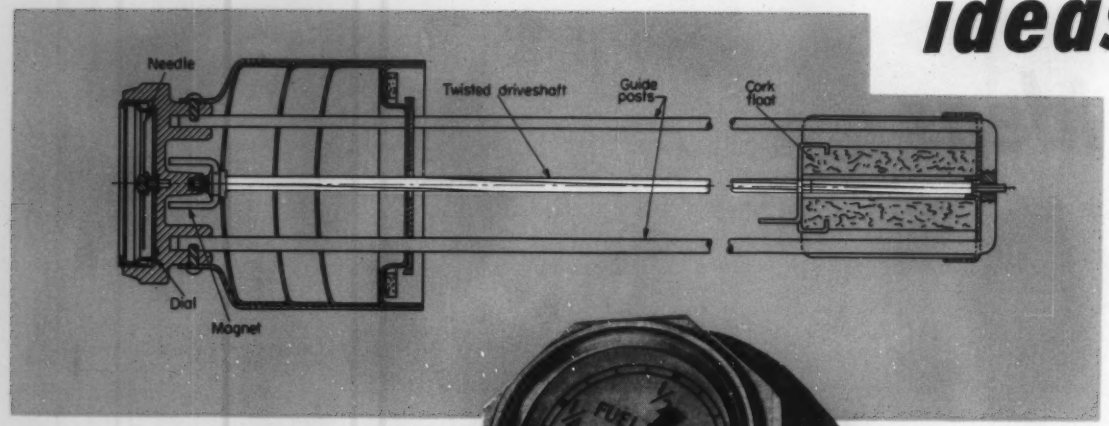
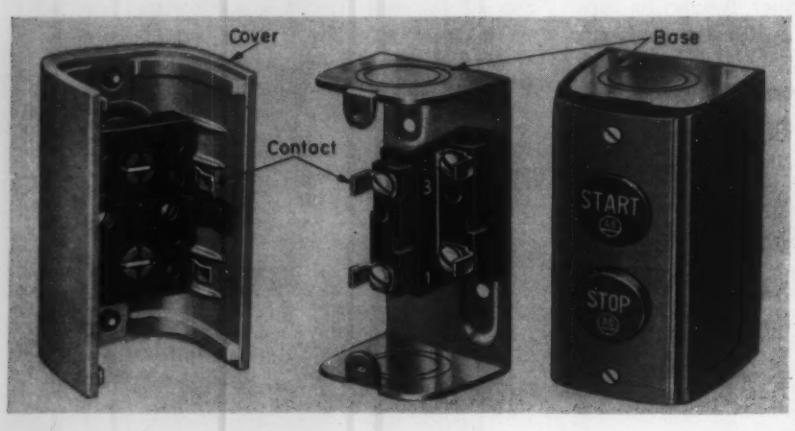
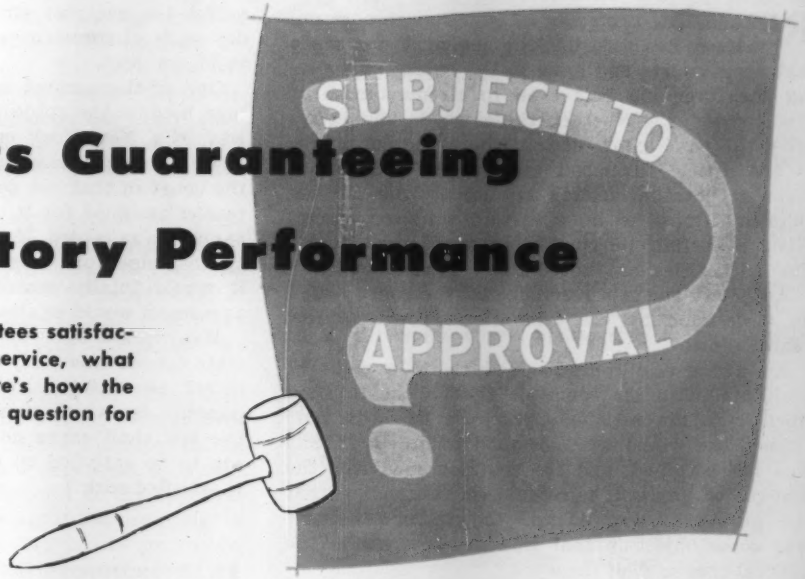


Twisted driveshaft is rotated by axial movement of a nonrotating "drive nut." In a simple, low-cost fuel gage developed by the Rochester Mfg. Co., a cork float is raised or lowered by changes in liquid level. Vertical movement of the float, which is prevented from "screwing" up the spiral-shaped rod by two guide posts, causes the rod to rotate. A magnetic field produced by a permanent magnet mounted on top of the driveshaft member induces the fuel-gage needle to follow driveshaft rotation, giving a visual indication of changes in the liquid level.

Wrap-around cover design on an electrical control both protects the contactor mechanism and exposes the terminals for easy wiring accessibility. In a line of switches designed by the Allen-Bradley Co., the operating mechanism is contained in a two-part enclosure. A base part, mounted on a supporting surface, contains the terminals; the wrap-around cover, which also forms the sides of the enclosure box, contains the contacts. The cover, when removed from the base, offers adequate protection for the contacts against damage from dropping or handling.



Contracts Guaranteeing Satisfactory Performance



When a contract guarantees satisfaction with a product or service, what does it really mean? Here's how the courts have answered this question for specific situations.

By **ALBERT WOODRUFF GRAY**
Forest Hills, N. Y.

TO MAKE a valid contract, both parties to the agreement must be bound to perform. However, when satisfactory performance is guaranteed as a condition of the contract, another factor is introduced. For more than a hundred years courts have struggled to define the "satisfaction" demanded by the law for performance of such contracts.

A CASE before a federal court in California many years ago[1] arose from a dispute over a contract for the sale of a fire engine. The manufacturer had agreed, "We will send the above described steam fire engine to Chico subject to the approval of the fire committee and will warrant the workmanship, finish and performance of the machine satisfactory to them or remove the same without expense."

When the engine was delivered it failed to receive the satisfaction and approval of the committee as had been stipulated in the sales contract. Suit was brought by the manufacturer. In its conclusion, the federal court said, "As the engine was to be furnished 'subject to the approval of the fire committee' and its performance warranted to be satisfactory to them and it was not approved by them and its performance was not satisfactory to them, there can be no recovery."

As grounds for this decision the court remarked that many authorities agree that when a contract contains the provision that an article shall be satisfactory to the buyer, and it is not, he is not required to accept it. "It is not enough that he ought to be satisfied with the article. He must be satisfied or he is not bound to accept it.

"While the wisdom of making an agreement of that character," added the court, "might be unwise, the seller making the agreement must be his own judge and if he deliberately makes such a contract he cannot recover if he fails to perform his agreement."

IN ANOTHER decision, the federal court[2] said of this rule of the law, "There is no doubt of the general proposition that where one party agrees to do a piece of work to the satisfaction of another, the excellence of which work is wholly or in part a matter of taste, . . . the buyer may reject it without assigning any reason for his dissatisfaction.

"In such case the law cannot relieve against the folly of the seller by inquiring whether the dissatisfaction of the buyer was based upon reasonable grounds or not. It is even doubtful whether

[1]References are tabulated at end of article.

it can inquire into the good faith of the purchaser's decision."

REGARDING contracts in which mere personal taste is not a factor, the comment was made that some courts had gone to the extent of applying the foregoing rule even to circumstances of this character. "Whether these words should receive the same construction where the suitability of the article furnished involves no question of taste or personal feeling but simply one of mechanical fitness to do a certain work or accomplish a certain purpose admits of some doubt. The authorities are not entirely harmonious."

Authority for this reference by the court rested on a decision by the Connecticut courts a few years before.

An artist was commissioned to do a piece of sculpture, with the condition that if the finished work were not satisfactory to the would-be purchaser, she would not be bound to accept it. She was not satisfied, and the sculptor sued[3] for the amount of payment agreed upon, contending that the purchaser was obliged to pay unless there was some objection that was not inherent in the general character of the work.

The court ruled that the sculptor, in failing to satisfy the customer, had not fulfilled his contract. It said, "It is not enough to say that she ought to be satisfied with it, and that her dissatisfaction is unreasonable. She and not the court is entitled to judge of that . . . . It may have been unwise in the sculptor to make such a contract, but having made it he is bound by it."

This decision stands as an authority for the exception to the rule that the dissatisfaction of the buyer must be such as might be entertained by a reasonable person.

WHILE the courts have generally followed the statement made in this old decision by the Connecticut Supreme Court, the interpretation of the word "satisfaction" in relation to articles other than those involving personal taste or preference involves even the validity of the contract itself—the absence of mutual obligations.

Provision in an agreement for the manufacture and delivery of exhaust fans for a western railroad was, in part, "We agree to furnish C. M. & St. P. Ry. Co. three 60-inch exhaust fans for their blacksmith shop, the same not to be paid for until satisfactory to the C. M. & St. P. Ry. Co."

The court said[4] in its denial of a recovery of the price agreed upon, "If the fans are not honestly and in good faith satisfactory to the purchaser and the purchaser notified the seller of that fact in a reasonable time, then and in that case there had been no sale and the purchaser is not liable for the price.

"To be satisfied is a fact and must be a verity and not a pretext. It is not, 'I will not accept it,—will not have it,'—but 'It is not satisfactory' or 'I am really and honestly dissatisfied with it.' This is implied in the very statement of the principle."

To this the court added the comment that many authorities hold that such a sale, imposing the satisfaction of the buyer as a condition of a sale, makes the contract strictly illusory and that under such circumstances there is no binding and valid contract.

One of the earliest incidents in which this feature became the subject of comment by the court was in a New York case[5] a century and a half ago: "A simple assertion of dissatisfaction," said the court in that old decision, "without some good reason assigned for it, might be mere pretext and cannot be regarded. If the buyer were left at liberty to judge for himself when he was satisfied, it would totally destroy the obligation and the agreement would be absolutely void."

Many years later the Court of Appeals[6] in that state echoed this early precept: "Such satisfaction is not an arbitrary or capricious one. It has its measure by which it can be defined. That which the law shall say a contract party ought in reason to be satisfied with, that the law will say he is satisfied with."

IN A controversy before the Massachusetts Supreme Court[7] the leaven of this idea becomes apparent: Dissatisfaction, to be within the meaning of a contract of this sort, must be substantial and not mere whim or caprice. A contract for the installation of a heating plant provided for payment "in the event of the system proving satisfactory and conforming with all the requirements as above provided for."

When suit was brought against the purchaser for the price he interposed the defense of his lack of satisfaction. Holding the seller entitled to a recovery irrespective of the purchaser's personal taste, it was said,

"The only question in this case is whether the written agreement between the parties left the right of the contractor to recover the price of the work and materials furnished by him, upon the actual satisfaction of the purchaser. Such agreements usually are construed not as making the purchaser's declaration of dissatisfaction conclusive, in which case it would be difficult to say that they amounted to contracts, but as requiring an honest expression."

The court went on to say that "when the consideration furnished is of such a nature that its value will be lost to the seller either wholly or in great part unless paid for, a just hesitation must be felt and clear language required before deciding that payment is left to the will or even to the idiosyncrasies of the interested party.

"In doubtful cases courts have been inclined to construe agreements of this class as agreements to do a thing in such a way as reasonably ought to satisfy the purchaser."

In conclusion it was said, "The satisfactoriness of the system and the risk taken by the seller were to be determined by the mind of a reasonable man and by the external measures set forth in the con-

tract, not by the private taste or liking of the defendent."

A RECENT case before the Alabama Court of Appeals involved a contract for material delivered "per your acceptance." The purchaser had appealed from a recovery by the seller. In its decision[8] sustaining that judgment the court summarized the interpretations of this many times litigated provision for work or services satisfactory to a contracting party.

"The phrase 'per your acceptance' we interpret as being analogous to and governed by the same rules as pertain to provisions in contracts where performance is to be to the satisfaction of the promisee. Such agreements like all others are enforceable according to the true interest of the parties.

"If a party voluntarily assumes the obligations and risks of an agreement by which he undertakes to furnish labor and material for a compensation, the payment of which is made dependent on a contingency so hazardous or doubtful as the approval or satisfaction of the other party, his legal rights are to be determined according to its provisions fairly construed and against the consequences resulting from his bargain the law can afford him no relief."

Then of the road traveled by the courts to this end, the opinion continued, "The difficulty of such cases lies in ascertaining the real intention of the parties. Rules laid down for such cases are really rules of interpretation and these are applied according to the station of the parties and the purposes they may appear to have had in view when entering into the contract."

Of the detailed application of this rule and its justification it was added, "This court seems to have accepted this general proposition, that to justify one party in his rejection of labor performed and material furnished by the other, on the ground that they were not satisfactory, as the contract provided that they should be, it must appear that the party seeking to avoid payment, according to the stipulation on his part, was in good faith dissatisfied and for some better reason than that he merely desired to avoid liability."

IN ITS conclusion the Alabama court made this brief survey of the principles that have been adopted generally by the courts throughout the country: "This doctrine is generally stated in substantially this form, that, to avoid liability after performance the dissatisfaction of the party for whom the work is done and material furnished must be genuine and caused by such defects or omissions as would cause a reasonable man to be dissatisfied."

Then of agreements of this type involving individual tastes and preferences, such as that of the Connecticut sculptor, "But it is commonly held that where the contract involves things intended to satisfy personal taste or feeling, the party to whom they are furnished is the free and exclusive judge whether they are satisfactory."

Of machinery specially designed or manufactured the court added in conclusion, "And substantially the same rule seems to be maintained in cases where machinery or special appliances have been furnished and the party to whom they are furnished after fair testing, alleges his dissatisfaction either with their mechanical utility or operative fitness for the purpose intended."

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4. Exhaust Ventilator Co. v. C. M. & St. P. Ry. Co., 28 *N. W.* 343, Wisconsin, May 15, 1886.
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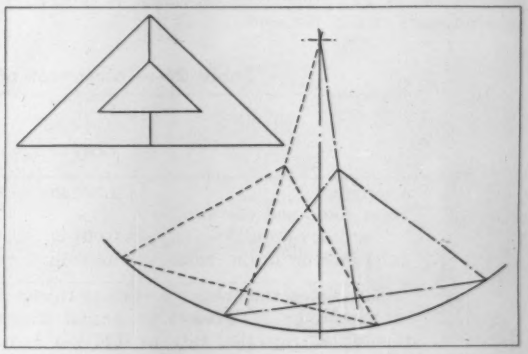
Tips and Techniques

Locating Arc Centers

The centers of large arcs can be readily found if a simple addition is made to a standard 45-degree triangle. With an accurate steel square and a scriber, make a line on the triangle from the 90-degree corner, perpendicular to the opposite side. A little india ink rubbed into the scratch will assure permanency. The triangle can be used to locate the center of an arc by placing its two acute-angle tips on the line of the arc and noting the scribed line on the drawing. The operation is repeated elsewhere along the arc and the lines extended to intersection. This intersection is the center of the arc.—WILLIAM J. LUSBY, *Philadelphia.*



DESIGNING WITH TEFLON

Part 4—Methods of Fabrication

METHODS for forming and fabricating Teflon tetrafluoroethylene plastics are somewhat different from those for other plastics. Machining is no more difficult, but requires extra attention. Bonding demands special techniques, but use of dispersions and films is similar if attention is paid to specific details.

Based on information supplied by E. I. du Pont de Nemours & Co. Inc., this series of articles has already covered properties of tetrafluoroethylene plastics. This fourth and final article covers forming and fabrication techniques which must be considered before a design is fixed.

▶ Molding, Machining, and Forming

Molding: Methods of molding have already been described in Part 1 of this series (Sept. 5 issue, Page 86).

Free-sintered moldings are subject to shrinkage from mold dimensions, which can be predicted by processers. But it should be obvious that looser tolerances are easier to meet and consequently less expensive than tight tolerances.

Practical tolerances for free-sintered cubes are shown in Table 25, and for flat rings in Table 26.* Both sets of tolerances presume that the processer can accurately predict nominal size of the part. This may require some ironing out of "bugs" in the molding process, so if double or even triple these tolerances can be allowed, lower costs may result. Tolerances are based on tests with a standard deviation of 3 sigma, in effect admitting possibility of rejection of about 0.27 per cent of the parts.

Machining: Molded Teflon plastic parts can be machined very readily with standard woodworking or metalworking tools, provided the tools are kept sharp. Both hand-fed and automatically fed screw machines are used. In general, high cutting

*F. M. Chapman, and L. T. Bunn—"Shrinkage of Moldings of 'Teflon' Polytetrafluoroethylene Resins," *SPE Journal*, Vol. 13, No. 2, February, 1956.

Table 25—Tolerances of Free-Sintered Cubes*

	Depth	Width	Thickness
Average dimension	0.964 in.	0.961 in.	1.078 in.
Total tolerance (3σ standard deviation)†	±0.006 in.	±0.005 in.	±0.010 in.
Tolerance on in./in. basis	±0.006	±0.005	±0.010

*25 samples made in hand-operated presses at preform pressure of 4000 psi, cooling rate of 45 F per hr and sintering time of 4 hr. †Based on actual dimensions; includes 99.73 per cent of cases—a theoretical rejection rate of 0.27 per cent.

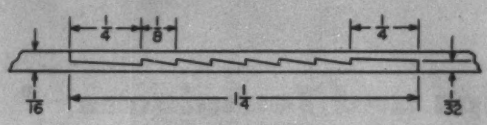
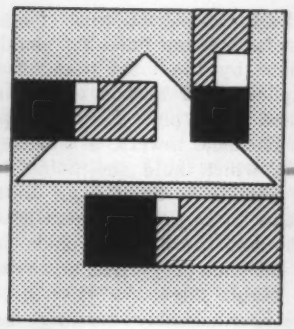


Fig. 42—Method of scarfing surfaces of Teflon plastic to make adhesive joint

Table 26—Tolerances of Free-Sintered Flat Rings

	OD	ID	Thickness	Weight	Thickness Corrected for Weight*
Average	1.924 in.	0.780 in.	0.382 in.	33.177 gm	0.382 in.
Total tolerance (3σ standard deviation)†	±0.004 in.	±0.002 in.	±0.024 in.	±2.05 gm	±0.002 in.
Tolerance on in./in. basis	±0.002 in.	±0.002 in.	±0.060 in.	.....	±0.006 in.

*Corrected thickness = (actual thickness) × (average, sample weight)/(actual sample weight). †Based on actual dimensions; includes 99.73 per cent of cases—a theoretical rejection rate of 0.27 per cent.



speeds with light cuts prove most satisfactory.

Tetrafluoroethylene resins have unusually high thermal expansion between 70 and 75 F which is discussed in detail in Part 3 (Oct. 3 issue, Page 124). When precision parts are gaged, it is necessary to determine stock temperature and make adequate allowances for thermal changes, so that final tolerances of the finished part will be maintained at its operating temperature.

Solid Teflon is readily machined to very close tolerances of ±0.001 in. if machining is done as follows:

1. Anneal the solid Teflon in air to a temperature above that at which it will operate for approximately 1 hr for each inch of cross section and cool slowly in a bed of silica-gel.
2. Rough machine oversize.
3. Repeat step 1.
4. Finish machine to required dimensions.

Forming: Tape and sheet stock of Teflon tetrafluoroethylene can be formed by drawing between male and female dies. Cold forming is adequate in many cases, though preheating to temperatures up to about 450 F is advantageous where extensive drawing is necessary. A depth of draw equivalent to one-half the diameter of the original sheet is obtained quite readily. Sheet stock can also be worked on a punch press to produce flat pieces. Thin-walled tubing can be flared with standard flaring tools used for copper tubing, and heavy tubing can be threaded with standard pipe-threaders in a manner similar to metal pipe.

Reinforced Compositions

One of the most promising developments is the use of tetrafluoroethylene resin as a binder for reinforcing agents such as coke flour, graphite, asbestos, talc, zircon, copper, and glass fibers. Modification of Teflon with reinforcing agents is attractive because it improves mechanical properties of the resin and reduces material cost. Selection of reinforcing materials can be tailored to a wide variety of chemical and electrical applications.

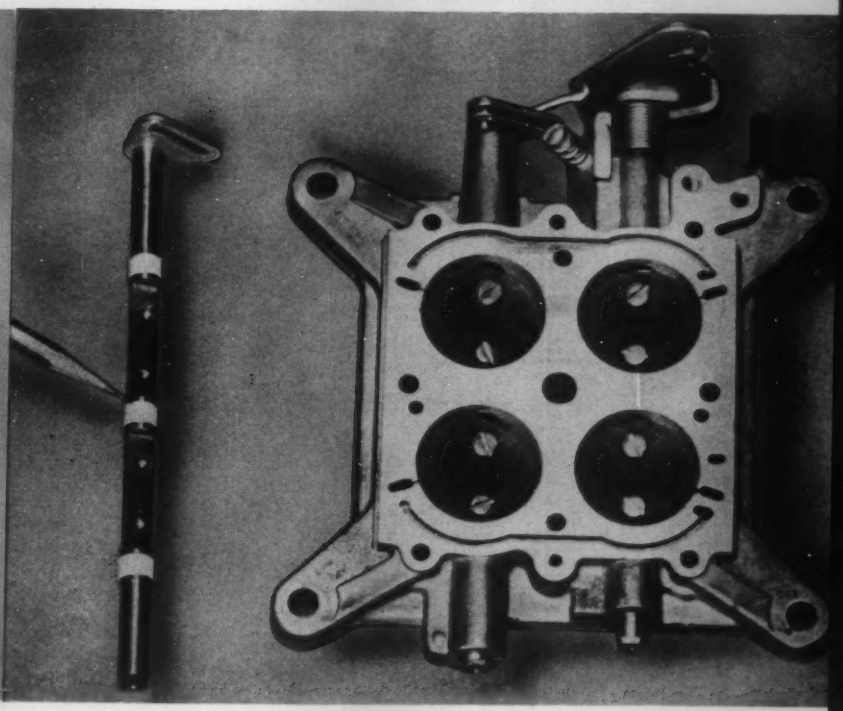
Reinforced compounds are prepared in two ways:

1. Simultaneous grinding of the tetrafluoroethylene resin and reinforcing agent.
2. Addition of reinforcing agent to an aqueous dispersion which is then coagulated, filtered, and dried.

Generally speaking, the latter method produces a composition with a higher reinforcing content

Carburetor Bearings

Carburetors in all 1957 models of two major car manufacturers have smooth-operating throttle shafts thanks to three tiny bearings of Teflon tetrafluoroethylene. Bearings eliminate tendency of valves to stick during acceleration or at high speeds. Smooth surface of Teflon retains self-lubricating properties during cold starts or through high-temperature operating conditions. Slip-stick action caused by gums in gasoline does not affect the Teflon. Teflon sleeve bearings eliminate chrome plating the throttle shaft; also reduce bearing costs from 7 cents each to 0.7 cent.



and better toughness.

The general effect of reinforcing materials on properties of Teflon resins is to increase stiffness, hardness, and compressive strength with a reduction in deformation under load and elongation. Usually, the quantity of reinforcing material that results in optimum properties is approximately 50 per cent by volume, proportion by weight varying according to density of reinforcing material. Some reinforcing materials produce compositions with outstanding properties. For example, a graphite composition has no water absorption and high thermal conductivity (19.5 Btu/sq ft/hr/in./deg F). An asbestos composition has an unusually high stiffness (modulus of elasticity equals 1,200,000 psi).

Heat Bonding of Joints

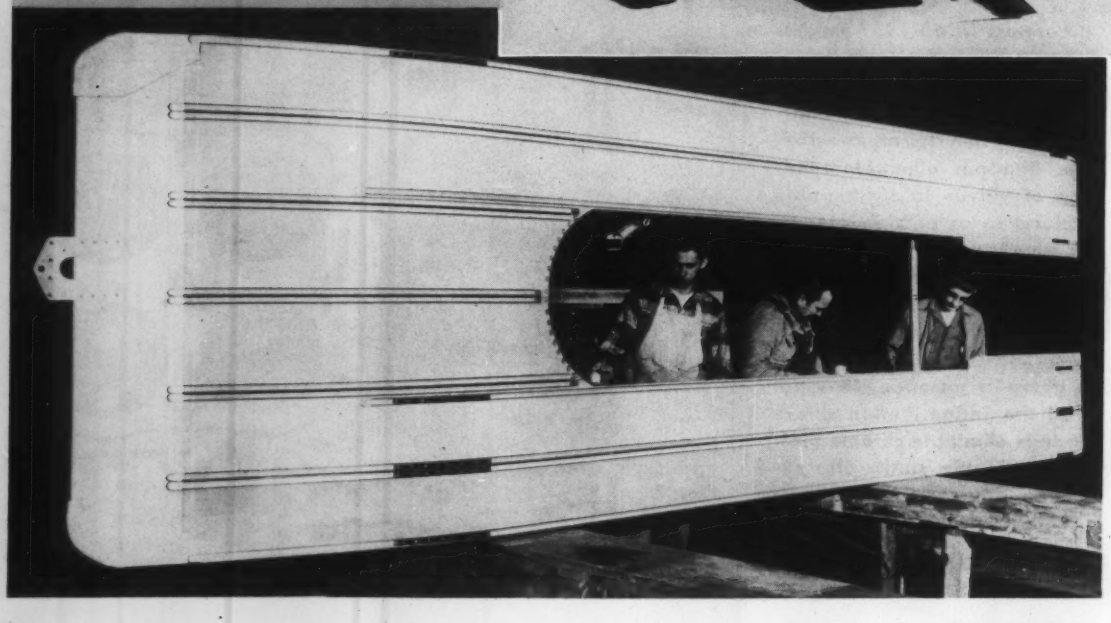
In lining equipment for chemical service, the best lining is obtained by heat bonding all joints of sheets of molded Teflon plastic. This results in a joint which is as strong and resistant to corrosion as the original sheet. The sheet is not physically bonded to the surfaces being lined but usually is supported in place by the lined item. For example, lining in pipe is held in position by a flared flange at each end of the pipe. Large equipment, such as vertical chemical towers, is fabricated in flanged sections which hold the lining in position in a manner similar to lined pipe. Side, top, and bottom nozzles in large equipment also serve as a means of holding the lining in place.

Because of Teflon's antistick properties, no chemically and thermally stable adhesives have been developed so far for permanently bonding unmodified sheets of molded tetrafluoroethylene resin to itself. Moreover, it is difficult to bond with a hot gas torch, since Teflon does not flow at elevated temperatures like other thermoplastic materials. These factors have limited use of Teflon to applications which do not require bonding of individual sections or sheets to form more complex shapes.

These limitations are largely removed by bonding sections of sheet stock with simple contact heaters at a temperature of about 700 F with the

Skins for Skis

Teflon ski skins for Lockheed C-130 troop carriers have been tested for arctic conditions. Slick Teflon surface reduces friction of bare metal on snow by 50 per cent and keeps the aircraft from freezing fast to ice. Sheets of 3/32-in. Teflon are bonded to the metal ski with an epoxy resin adhesive.



aid of a flux-like material under a contact pressure of about 35 psi.

Thickness Requirements: Sections having a thickness of 1/16 in. are most suitable for bonding and have the mechanical properties needed for fabrication. Thicker sections also can be bonded, but more time is required for the heat transfer operation. Thinner sheets can be joined easily, but they have less strength to absorb thermal stresses and more care is required during the bonding operation to prevent any permanent deformation of the joint. All sheet stock of Teflon used for bonding should be stress relieved for 2 hr at 90 F above the maximum service temperature.

Scarfed Surfaces for Joints: Scarf joints are well suited for bonding. They avoid the bulky double thickness of a lap joint and allow tight closures at flanged joints. Their chamfered edges can be obtained with a rotary cutter on a milling machine. To increase the contact area and to assist alignment, the scarfed surfaces can be grooved by filing small ridges into the milling tool. A sharp feather edge is not desirable since it may tend to warp when heated. A cross section of the joint which has the greatest strength is shown in Fig. 42.

Use of Flux: Joints of sheeting bonded with flux have substantially higher peel strength than those joined without flux.

Flux is prepared by intimately mixing 65 parts of a fluorocarbon oil* with 35 parts of unsintered powdered Teflon 6. Hand or mechanical blending is satisfactory, but preferably the flux should be prepared and applied at about 149 F since the fluorocarbon oil is quite viscous at room temperature. Particular care should be taken that the grooves in the contact areas are uniformly coated with this paste. Excess flux can be saved for future use as it appears to have unlimited shelf life.

Heaters and Heater Presses: Electrical contact heaters required to supply the necessary heat should provide heat uniformly over the entire contact area. They should be able to heat up to a temperature of 750 F and should be made adjustable by means of a 110 or 235-v powerstat.

Some commercially available heaters have hot spots which are difficult to control. These are highly undesirable as they cause local overheating. Similarly, undesirable cold spots are frequently found at both ends of straight contact heaters or in the middle of circular heaters where lead-in wires are attached. Cold spots give poor bonds which require resealing to insure uniform bond strength.

To obtain a more even heat distribution, metal plates with efficient heat transfer properties should be attached to the heaters. Thus, ⅛-in. thick aluminum or copper plates can be attached facing the contact heaters with one side and Teflon resin with the other, Fig. 43. Heaters can be constructed so that heating coils or wires are arranged to give the required even distribution of heat.

Curved and circular shaped bonds can be obtained by use of ring element contact heaters. These heaters are available in many standard sizes. They can be adapted to fit many nonstandard sizes by using ⅛-in. thick aluminum plates at the interfaces to match the desired dimensions of the joint.

Both straight and circular heaters can be bolted or welded to adjustable heater presses. These are particularly useful where the same type of bond must be duplicated frequently. Hydraulic presses offer the advantage of uniform pressure distribution and rapid assembly.

The two surfaces, both previously coated with flux, are joined intimately with the above heaters with C-clamps, heater presses, or other adjustable clamping devices, Fig. 43.

Care should be taken to maintain an even pressure all along the bonding area. As the sheet expands during heating, pressure at the contact area will increase automatically until the sintering temperature is reached (520 F). An initial contact pressure of about 35 to 50 psi is recommended. If this is exceeded, there is danger of damaging the bond by extruding the tetrafluoroethylene resin once the sintering temperature is passed.

Heaters are then brought to a temperature of about 700 F by adjustable voltage regulators. For better temperature control or for experimental purposes, thermocouples can be inserted at the bonding area, but care should be taken not to leave a weak spot at the point of insertion. Satisfactory control of temperature can be obtained by calibrating the voltage regulators before use.

Once the bonding temperature is reached, it should be maintained for 5 to 10 minutes until substantially all the fluorocarbon oil has been volatilized. No harm is done by continued heating, although the maximum bonding temperature of 740 F should never be exceeded, as pyrolysis of the Teflon tetrafluoroethylene resin will start. After bonding

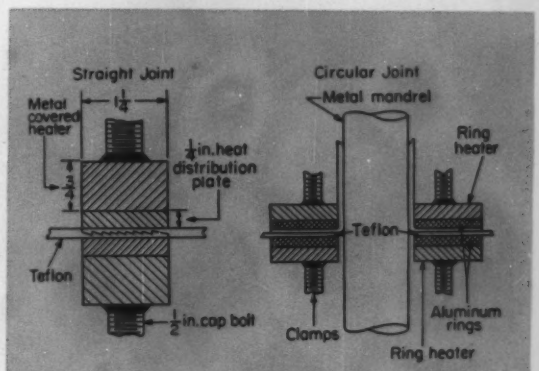


Fig. 43—Joining operation for Teflon, showing ways to use heaters

*Fluorolube LG (fluorinated hydrocarbon), Hooker Electrochemical Co., Niagara Falls, N. Y.

is completed, the heaters are allowed to cool without removing pressure until the polymer is below 200 F. When heaters are removed, excess flux is wiped off.

Strength of Bonded Joints: Joints of sheets that have been properly heat bonded are stronger than adjacent sheet material even after exposure to solutions shown in Tables 27 and 28. None of the samples tested failed at the bonded joint.

Cementable Tape: Various processers have developed patented procedures for preparing articles of Teflon resins having special surfaces to which conventional adhesives will bond. As a result, good bonding strength can be achieved between tetrafluoroethylene plastic and wood, glass, steel, aluminum, copper, ceramics, plastics and, in fact, any material that will bond with an adhesive.

This development has opened up new applications where a material with antistick qualities and excellent frictional properties is required at elevated temperatures and under severe corrosive conditions. Parts fabricated of Teflon will withstand temperatures to 500 F. However, the adhesive may be the limiting factor at elevated temperatures, and its maximum service temperature should be established.

For instance, one treatment is a patented process (Minnesota Mining & Mfg. Co.) using a solution of sodium and liquid ammonia.

The treated sheet is bonded to other surfaces in the same way as other materials with an adhesive. In the case of cementable tape, the adhesive used determines the chemical and solvent resistance of the installation, and due consideration must be given to the choice of adhesive under these conditions. Some adhesives which have been used successfully are listed in Table 29.

For installations exposed to ultraviolet light, cementable tape containing a 2 per cent (weight) dispersion of carbon black is recommended to prevent deterioration of the cementable surface.

Bond strengths between treated tape and various substrates are shown in Table 30. Relative bond strengths between treated surfaces of tape for various adhesives after chemical exposure are shown in Table 31.

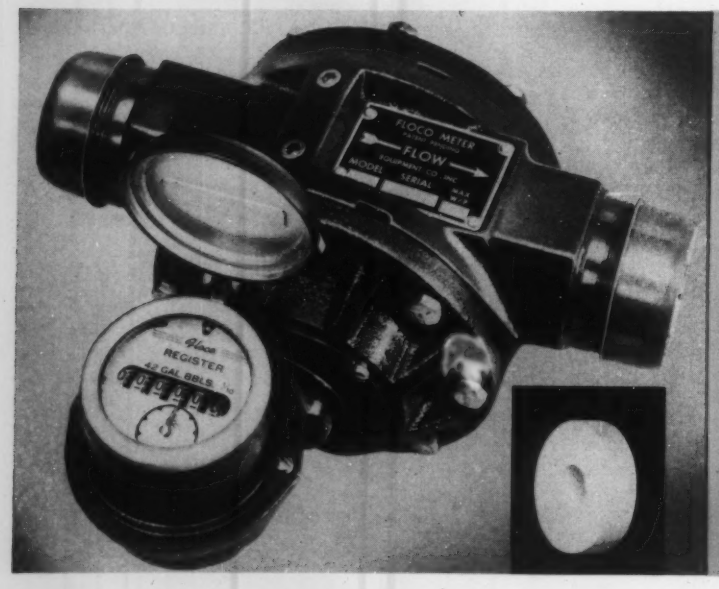
Teflon Dispersions

Teflon 30 dispersion is a milky white liquid consisting of very small particles of tetrafluoroethylene resin suspended in water. The utility of the dispersion lies in its fluid form; the resin cannot be prepared in a fluid state by melting or by solution. Fundamentally, the polymer in the dispersion is exactly the same as the polymer supplied in powder form for molding and extrusion and has the inherent properties of Teflon tetrafluoroethylene resin.

Teflon 30 dispersion, as supplied, contains 59 to 61 per cent (by weight) tetrafluoroethylene resin and 5.5 to 6.5 per cent of this weight as Triton X100 (Rohm & Haas Inc.), a nonionic wetting agent.

Uses for this material are found in operations involving coating, impregnation, and blending such as:

1. Cast film for capacitor insulation and diaphragms.
2. Impregnated glass fabric, mats, and laminates for electrical insulation in motors, generators, and transformers; wrapped insulation on wire for high temperature application; nonadhesive separator sheets for laminating and press blankets; chemically resistant protective clothing; gaskets.
3. Impregnated asbestos and fabric of terafluoroethylene resin and braid for gasket and packing



Seals for Meters

Meters for measuring the flow of crude oil relies on bearing seals of Teflon to resist effects of petroleum chemicals and suspended abrasives such as sand. Clogging is also prevented since waxes in the oils will not adhere to the slick bearing surfaces.

uses.

4. Finishes for nonadhesive coatings on bread pans.
5. Wire enamels for magnet wire in small relays, transformers, and motors.
6. Blends with other resins and fillers.

Blends and Codispersions: Homogeneous mixtures of tetrafluoroethylene resins with a variety of materials can be prepared from the dispersion. Solid materials should be in a finely divided state, and the best results will usually be obtained by suspending the solid in water before mixing with the dispersion. Immiscible liquid systems can frequently be processed through the use of mutually miscible solvents such as acetone or alcohol. However, the resin will coagulate immediately on mixing.

Stable codispersions of Teflon tetrafluoroethylene resins with other aqueous systems can be obtained in some cases. For example, rubber lattices can be mixed with the dispersion, provided that three precautions are observed: The system should be free of electrolytes, particle size of the rubber should be of the same order of magnitude as the Teflon tetrafluoroethylene resin, and no water miscible solvents can be present.

Enamels: Enamels of Teflon resins are supplied in color for application to wire and flat surfaces by dipping, spraying, or brushing. Application usually involves a prime and finish coat.

Impregnation: A variety of porous structures have been impregnated with Teflon resins by treatment with the dispersion. The dispersion is a good impregnating agent, because it has low viscosity, consists of extremely small particles of resin, and wets the surfaces of the interstices, promoting capillary action. After dipping and drying, the deposit of tetrafluoroethylene resin may be sintered, depending on requirements.

Baked coatings on woven fabrics and mats of glass or asbestos fibers are prepared by much the same procedure as described for cast films. In preparing the fabric for impregnation, combustible sizing agents should be removed by prebaking. Also, soluble electrolytes should be removed by washing, since they may coagulate the dispersion in the impregnation bath. Strong laminates can be obtained by stacking impregnated fabrics in piles and baking under pressure at 675 to 700 F.

Impregnated materials with the chemical resistance and nonadhesive property of tetrafluoroethylene can be prepared without sintering the de-

Table 27—Tensile Strength of Heat-Bonded Scarf Joints

(Exposure to Indicated Solutions at Reflux Conditions)

Solution	Reflux Time (hr)	Tensile Strength* Room Temp. (psi)	Tensile Strength* 212 F (psi)
Acetone	48	2540	1780
Benzene	48	2270	1560
Carbon tetrachloride	48	2180	1330
Cetane	48	1580	1515
Cyclohexane	72	2440	....
10% Sulfuric acid	48	1985	1540
10% Hydrochloric acid	72	1965	....
10% Phosphoric acid	72	2295	....
10% Nitric acid	72	2460	....
10% Acetic acid	72	2465	....
10% Sodium hydroxide	48	2160	....
Unexposed control	..	2240	1260

Tested on Instron, Cell D; crosshead speed, 2 in. per min; 2 in. jaw distance. *Failure occurred before any of the bonds separated.

Table 28—Peel Strength of Heat Bonded Joints

Solution	Peel Strength Room Temp. (lb/0.5 in. width)	Peel Strength 212 F (lb/0.5 in. width)
Acetone	19.5	29.6
Benzene	16.6	16.6
Carbon tetrachloride	18.3	35.0
Cetane	16.1	28.0
10% Sulfuric acid	23.3	31.0
10% Sodium hydroxide	19.6	29.1
Unexposed control	21.0	24.1

Tested on Instron, Cell D; crosshead speed, 2 in. per min, 1 in. jaw distance; exposure to solutions for 48 hr at a reflux condition.

Table 29—Sources for Teflon Adhesives

Adhesive	Type	Supplier
Bonding Agent, R-313	Epoxy	Carl H. Biggs Co. Inc. 2255 Barry Avenue Los Angeles, Calif.
Bondmaster, M-24 Bondmaster, M611	Epoxy	Rubber and Asbestos Corp. 225 Belleville Ave. Bloomfield, N. J.
Plymaster, V-2	Glass-reinforced epoxy	Rubber and Asbestos Corp. 225 Belleville Ave. Bloomfield, N. J.
Miracle Adweld Adhesive W-799	Epoxy	Miracle Adhesives Corp. 214 East 53rd St. New York, New York
Miracle Epoxy Resin Complex NP285	Epoxy	Miracle Adhesives Corp. 214 East 53rd St. New York, New York
Penacolite Adhesive, G-1124	Resorcinol-formaldehyde	Koppers Co. Inc. Pittsburgh, Penna.
Phenoline, 300	Phenolic	Carboline Co. 7603 Forsyth Blvd. St. Louis, Mo.

Table 30—Bond Strengths for Several Adhesives

(Treated tape of Teflon tetrafluoroethylene resin)

Substrate	Adhesive* R-313 (lb/in.)	Adhesive* M611 (lb/in.)	Adhesive* NP285 (lb/in.)
Tapes of Teflon tetrafluoroethylene resin	40.5	30.2	31.7
Rubber	8.0	12.4	3.8
Neoprene	10.6	10.2	10.8
Wood	37.8	41.3	35.5
Steel	62.8	58.7	49.8
Aluminum	45.0	51.2	45.5

*See Table 29 for identification.

Table 31—Relative Bond Strengths Between Treated Teflon Sheets After Chemical Exposure

Chemical at 73 F	Adhesive* Phenoline 300 (per cent)	Adhesive* R-313 (per cent)	Adhesive* NP285 (per cent)	Adhesive* M611 (per cent)
Control relative to R-313	73	100	77	100
50% ethyl alcohol	29	81	84	100
Carbon tetrachloride	88	80	75	96
Toluene	41	66	75	73
Acetone	10	57	52	82
5% Acetic acid	32	64	74	86
10% Nitric acid	55	50	120	79
10% Hydrochloric acid	35	89	73	89
30% Sulfuric acid	38	91	†	86
10% Sodium hydroxide	18	66	74	82

*See Table 29 for identification. †No data available.

posited polymer. This involves merely dipping and drying, though pressure is usually applied to the impregnated material either before or after drying to aid in holding the resin in place. For example, a fabric or mat material can be calendered continuously as an integral part of the treatment, or the dried material can be compressed in a mold as an after-treatment. This permits fibers of less heat resistance than glass and asbestos to be used for certain applications.

Casting Film: This process involves the application of Teflon 30 to a surface by dipping, flowing, or spraying, followed by drying and baking.

Dip coating has proved preferable in most cases because of its adaptability to continuous application of a uniform coating. A dispersion concentration of 45 to 50 per cent solids by weight and 9 to 12 per cent (of this solids weight) Triton is recommended for optimum wetting characteristics.

Thickness of dispersion layer picked up during each dip should be limited to about 1 mil to avoid "mud cracking" upon drying and to permit rapid vaporization of the dispersing agent during the sintering operation. Amount of pickup is influenced by viscosity of the dispersion, coating speed, and roughness of the surface being coated, but it can be controlled very readily by an air jet used as a doctor knife. As many coats may be applied as desired, provided each is sintered before applying the following coat.

After the coat is dipped, the next step is to remove water from the deposited dispersion. This may be done under infra-red lamps or in a forced-convection air oven. Oven drying is faster; for example, it takes about 15 seconds to dry a 1 mil film under infrared lamps, while this can be accomplished in about 5 seconds by forced convection.

Drying is followed by a baking and sintering operation, during which two things occur simultaneously—the Triton is volatilized, and the discrete particles of the resin are sintered into a homogeneous film. This is carried out in an air oven maintained at a temperature of about 700 F, though temperatures of 675 to 750 F can be used. Sintering of tetrafluoroethylene particles takes place almost instantaneously on reaching the required temperature.

Most of the stabilizer is volatilized relatively quickly, but a small amount decomposes, leaving a minute carbonaceous residue that will be removed by oxidation on continued baking. Whether or not this residue should be baked out depends on the particular application; it causes discoloration, detracts from electrical properties, and makes stripping the film off the surface very difficult. If none of these effects are important, the baking cycle can be relatively short—about 3 minutes for a 1-mil film. However, for complete removal of stabilizer residues, a baking cycle af about 8 minutes is necessary for a 1-mil film. Hence, multiple applications of 1-mil each are more desirable from the standpoint of baking time, even if the critical thickness were great enough to permit thicker deposits in a single cycle. Multiple dips, with baking between dips, results in good homogeneity with no evidence of a laminar structure.

When unsupported film is being made by casting, the final step is to strip the film from the metal surface. Rapid cooling of the film from the sintering temperature by quenching in cold air or water promotes ease of stripping. By the same token, slow cooling and even annealing promote good adhesion. Other factors that facilitate stripping are complete removal of Triton and maintenance of a metallic surface free of corrosion and in a fairly high state of polish. When the same surface is used repeatedly, corrosion at the high temperatures employed in the sintering oven becomes a problem. Ordinary steel and even stainless steel corrode rapidly, while nickel, chromium, and silver are more resistant. Nickel appears to give the best results. Washing the surface in dilute acid and buffing after stripping each film are helpful.

The foregoing procedure is based on rather limited study of the variables involved in casting films from Teflon dispersion. Undoubtedly, modifications to meet specific needs can be made to advantage.

Marking: Inks have been developed which can be used to print items fabricated of Teflon tetrafluoroethylene resins. Also, colors can be added to the resin for color coding when necessary. Thus, conventional assembly operations based on color coding can be accommodated.

Fabrics: Fibers of Teflon, which have the same chemical resistance as the rigid material, can be woven into cloth just as readily as other fibers. Felt of Teflon is also produced and used where corrosive materials are present.

They Say . . .

"Recognition, by engineering management, of the importance of good mechanical design in contributing to the reliability of electronic equipment is the first step in overcoming deficiencies. A well-organized program of training, standardization, mechanical design reviews by specialists, and environmental testing during the design phase, must then follow."—L. JACOBS, *Radio Corp. of America, Moorestown, N. J.*

Centering Reel for Steel Coils

The expansible-arbor centering reel described on Page 148 of the September 19, 1957, issue of MACHINE DESIGN is built to handle steel coils instead of rolls of paper as stated in the write-up. The reel is designed and built by Sesco Inc., Detroit, Mich.

Step-by-step methods for finding

Combined Blower-Motor Performance

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Operating point of a blower-motor combination—say, one that cools an electronic rig—can be predicted by matching the individual characteristics of the components. This article shows how to organize the matching problem and gives step-by-step methods for calculating performance.

PERFORMANCE characteristics of blower-motor combinations like those used for cooling electronic equipment, either ground or airborne, must frequently be calculated in advance of installation. The aim is to minimize the time and cost involved in actual operating tests on the prototype. Often a blower-motor cooling unit that has operated successfully in one application may be proposed for use in an entirely different system. Its probable performance in the new system must, of course, be determined. Or, in another common case, the performance characteristics and electrical input requirements of a particular blower-motor combination may be known at a given operating point at sea level; problem is to obtain these values at other altitudes.

Performances of a blower and motor working together are so interrelated through rotational speed that the operating characteristics of each cannot be treated separately. In Fig. 1, for example, performance curves[1] for a 5-in. by 7/16-in. blower wheel, widely used in airborne cooling applications, give total pressure p_t, blower efficiency η, and brake horsepower P_b as functions of flow rate Q at sea level (constant air density = 0.0765 lb per cu ft and shaft speed = 6100 rpm). In a hypothetical example, the operating point Q_o = 120 cfm and p_{to} = 6.0 in. of water may represent the performance that is required of this blower in a

[1]References are tabulated at end of article.

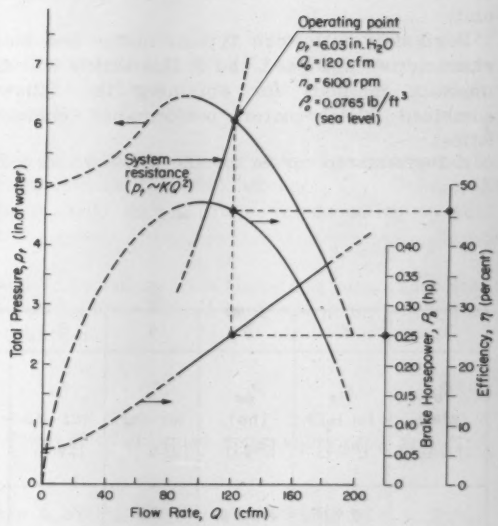


Fig. 1—Performance of typical 5 in. by 7/16-in. blower wheel at sea level (ρ = 0.0765 lb per cu ft). Speed is 6100 rpm.

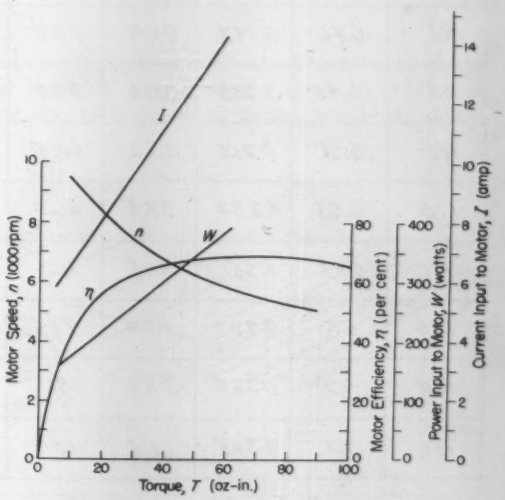


Fig. 2—Characteristics of typical dc series motor rated 0.30-hp at 27 v.

particular cooling system. Through this operating point (probably measured), a system resistance curve can be drawn, Fig. 1, since total pressure in a given system is approximately proportional to the square of the flow rate.

Cooling blowers like that with characteristics of Fig. 1 are driven by motors with torque output at the blower shaft varying in some degree with motor speed. The blower, for example, might be driven by a 0.30-hp, dc series motor, with speed n, efficiency η power input W and current I varying with torque output, Fig. 2. Only through pure chance would the motor generate at 6100 rpm the torque required to sustain the blower flow rate at the hypothetical operating point in Fig. 1. Performance curves must therefore be developed so as to represent the blower and motor operating as a unit.

Beginning with such typical motor and blower characteristics, Figs. 1 and 2, this article will demonstrate methods for obtaining the following combined blower-motor performance characteristics:

1. Performance curves for the blower-motor unit operating at constant air density—sea level, for example—in cooling applications where system resistances differ.
2. Performance curves as a function of altitude (variable air density) for the blower-motor unit running at a fixed operating point. A given mechanical system with a constant resistance curve is assumed.

In such procedures, static pressure p_s is best used as the pressure characteristic of the blower if most of the velocity energy is recovered for use at the blower discharge. If not, it is preferable to use total pressure p_t.

Varying System Resistance

While performance curves can, in the manner described here, be determined for any constant air density (or altitude), the object of this first example is to illustrate methods for determining total pressure p_t, speed n, power input W and current input I to the motor as functions of Q for the blower-motor unit operating at sea level. To

1	2	3	4	5	6	7	8	9	10	11	12
Q_o (cfm) [Fig. 1]	p_{to} (in. H_2O) [Fig. 1]	P_{bo} (hp) [Fig. 1]	T_o (oz-in.) [Eq. 1]	T_c (oz-in.) [Eq. 2]	T_o (oz-in.) [Fig. 4]	n_o (rpm) [Fig. 4]	$\frac{n_o}{n_o}$	Q_o (cfm) [Eq. 3]	p_{to} (in. H_2O) [Eq. 4]	W (watts) [Fig. 2]	I (amp) [Fig. 2]
0	4.93	0.056	9.3	16.0	17.8	8550	1.40	0	9.65	208	7.8
40	5.4	0.097	16.2	27.9	26.1	7830	1.28	51	8.85	244	9.1
80	6.4	0.173	28.6	49.2	37.5	6950	1.14	91	8.32	292	10.9
90	6.46	0.193	31.9	54.8	40.0	6830	1.12	101	8.10	303	11.2
95	6.45	0.203	33.6	57.8	41.8	6740	1.11	105	7.95	310	11.5
100	6.38	0.213	35.2	60.6	42.5	6700	1.10	110	7.72	313	11.7
110	6.23	0.232	38.4	66.0	44.6	6580	1.08	119	7.26	323	12.0
120	6.03	0.251	41.5	71.3	46.7	6460	1.06	128	6.78	330	12.2
140	5.5	0.287	47.4	81.5	50.2	6270	1.03	144	5.84	346	12.8
160	4.7	0.320	53.0	91	53	6100	1.00	160	4.7	358	13.3
180	3.7	0.365	60.5	104	58	5950	.98	176	3.6	380	14.0

Fig. 3—Blower-motor characteristics, obtained by the step-by-step procedure, can be organized and the results itemized in tabular form. Numerical values given here are results of sample calculations in the text and are illustrative only.

simplify calculation and tabulation of data, the calculation table in Fig. 3 is used. Following are the recommended steps for obtaining blower-motor performance curves when system resistances differ:

Step 1: Record values of p_t and P_b for a number of values of Q (each value representing a different operating point) along the p_t vs. Q curve for the blower. Values of Q selected should cover the useable portion of the p_s vs. Q curve, that is, the upper part of the slope right of the peak-pressure point.

Values of P_{lo} and P_{bo} are given in columns 2 and 3 of Fig. 3 for 11 values of Q_o in column 1. Note that these values are bunched at critical parts of the curve near the peak in Fig. 1. Several values have been selected in the unuseable range to the left of the peak (dashed) to demonstrate the shape of the curves obtained at lower flow rates.

Step 2: Calculate T_o from

$$T_o = \frac{(1.01 \times 10^6) P_{bo}}{n_o} \text{ oz-in.} \qquad (1)$$

This gives the original torque value for each value of P_{bo} and original speed n_o. The value of T_o in the example (column 4, Fig. 3) is obtained from P_{bo} (column 3) and $n_o = 6100$ rpm.

Step 3: Calculate T_c from

$$T_c = T_o \left(\frac{n_c}{n_o} \right)^2 \text{ oz-in.} \qquad (2)$$

Several such values can be calculated for each value of T_o corresponding to different operating speeds, n_c. In this example, an operating speed, $n_c = 8000$ rpm has been used for the sample calculations in Fig. 3.

Step 4: For each value of flow rate, plot torques T_o and T_c (columns 4 and 5) on the speed-torque curve for the motor. Join points at T_o and T_c for each flow rate with a straight line. The straight line then represents the speed-torque characteristic of the blower at that particular flow rate (or operating point). Since blower torque is proportional to the square of speed, straight lines through two torque points can only be drawn when the motor speed-torque curve is plotted on log-log paper. If the speed-torque characteristic of the motor is plotted on linear graph paper, it is necessary to pick several additional points near the motor speed-torque curve. Each of the blower speed-torque characteristics is a curve line on a linear plot, and its intersection with the motor speed-torque curve must be carefully determined if results are to be accurate.

The intersection of each blower speed-torque line with the motor speed-torque curve gives the actual motor torque output and blower-motor speed at that particular blower operating point. Eleven such points of intersections are shown on the log-log graph in Fig. 4.

Step 5: Record in the calculation table values of actual torque and speed (T_a and n_a) at the curve intersections. Data from Fig. 4 are recorded in columns 6 and 7, Fig. 3.

Step 6: Calculate n_a/n_o (ratio of actual speed to original constant speed) at each Q_o. Column 8 gives $n_a/6100$ for a range values of n_a in column 7.

Step 7: Calculate with the speed ratio from Step 6 the actual flow rate at each operating point from the equation

$$Q_a = Q_o \left(\frac{n_a}{n_o} \right) \text{ cfm} \qquad (3)$$

Column 9 is obtained from columns 1 and 8 in Fig. 3.

Step 8: Calculate the actual value of total pressure (p_{ta}) at each value of Q_a from

$$p_{ta} = p_{to} \left(\frac{n_a}{n_o} \right)^2 \text{ in. of water} \qquad (4)$$

Column 10 is obtained from columns 2 and 8 in Fig. 3.

Step 9: Record in the calculation table motor power input W and current I given in the motor curves for each value of actual torque T_a deter-

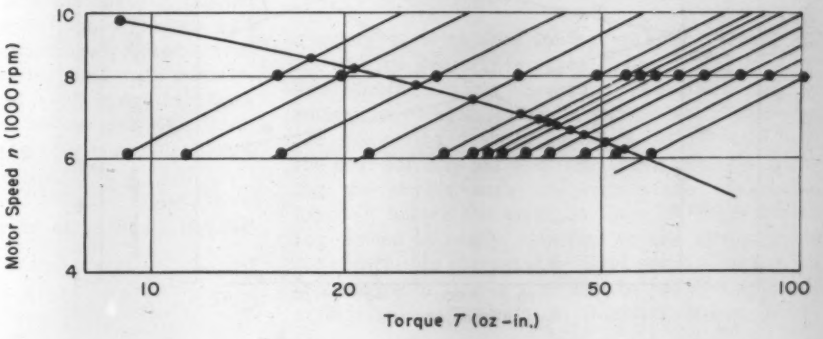


Fig. 4 — Intersections of blower speed-torque and motor speed-torque characteristics give operating points for a blower-motor combination.

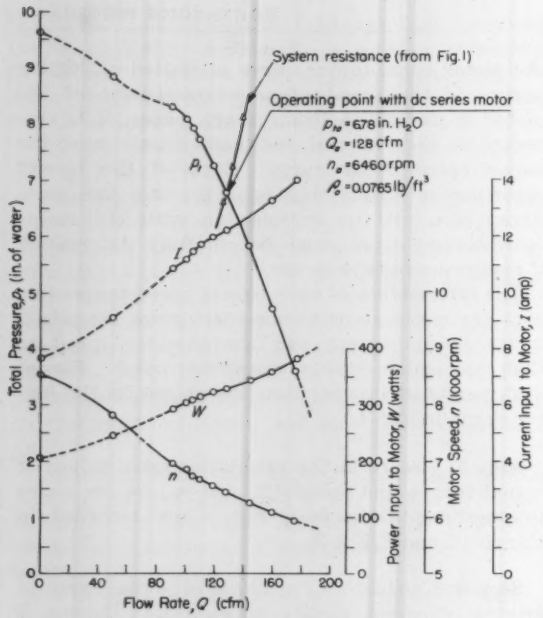

System resistance (from Fig. 1)
Operating point with dc series motor
p_{ta} = 6.78 in. H_2O
Q_a = 128 cfm
n_a = 6460 rpm
ρ_o = 0.0765 lb/ft³
Total Pressure, p_t (in. of water)
Power Input to Motor, W (watts)
Motor Speed, n (1000 rpm)
Current Input to Motor, I (amp)
Flow Rate, Q (cfm)

Fig. 5—Performance for combined blower-motor.

mined in Step 5.

These data, derived from Fig. 2 and column 6, are recorded in columns 11 and 12 of Fig. 3.

Step 10: Plot actual values of total pressure p_{ta}, power input W, speed n_a, and current input I as functions of actual flow rate Q_a. The resulting performance curves represent the performance of the blower and motor as an operating unit. That is, they give the air-flow output of the blower and the electrical input and speed of the motor.

Four such curves are plotted in Fig. 5. Useable flow-rate ranges are dashed below the peak.

It is evident from the differences between the total-pressure curves in Figs. 1 and 5 that a drop in motor speed with increasing flow has a substantial effect on blower performance.

Note that the original system-resistance curve (Fig. 1), replotted in Fig. 5, intersects the total-pressure curve at a new location for the operating point, that is, at p_{ta} = 6.78 in. of water, Q_a = 128 cfm and n_a = 6460 rpm. Thus, while the original location of the operating point (Fig. 1) is achieved with this blower wheel at a speed of 6100 rpm, use of the dc series motor to drive the wheel (with

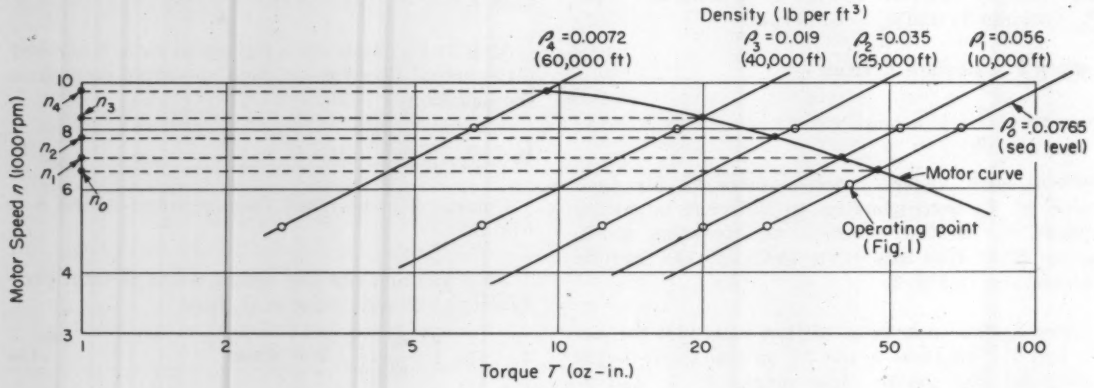

Density (lb per ft³)
ρ_4 = 0.0072 (60,000 ft)
ρ_3 = 0.019 (40,000 ft)
ρ_2 = 0.035 (25,000 ft)
ρ_1 = 0.056 (10,000 ft)
ρ_o = 0.0765 (sea level)
Motor curve
Operating point (Fig. 1)
Motor Speed n (1000 rpm)
Torque T (oz-in.)

Fig. 6—Above—Blower torque-speed characteristics at various densities (altitudes).

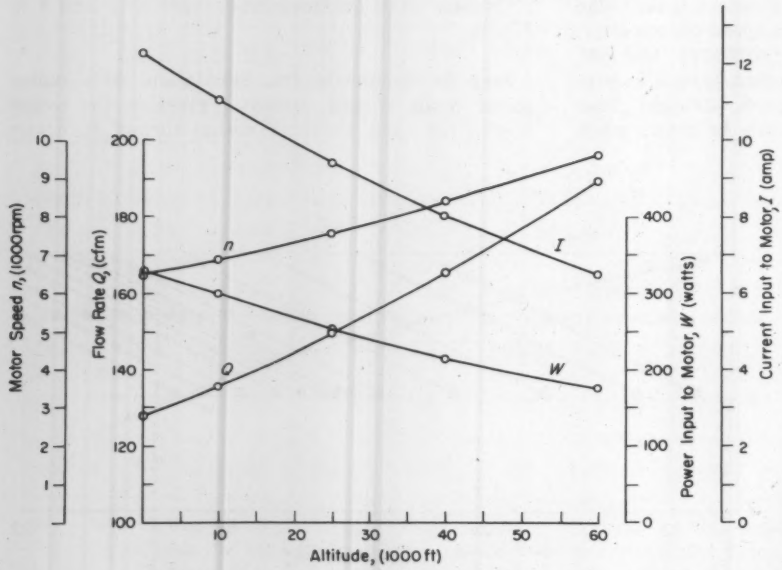


Fig. 7.—Left—Altitude performance of 5 in. by 7/16-in. blower driven by 0.30-hp dc motor.

the characteristics of Fig. 2) has resulted in a shift to a new operating point. In this particular case, the amount of the shift does not seem sufficient to require an alternate blower or motor.

The operating point of the blower-motor unit in any system and at constant air density may be determined on the performance curves by constructing a system-resistance curve on the basis of actual measured flow and pressure.

▶ Varying Density

Whatever the changes in motor speed or air density, a blower wheel like that in Fig. 1 is considered to be running at the same operating point — that is, at the same intersection of total-pressure and system-resistance curves—as long as it is cooling a fixed mechanical system with constant resistance characteristics. To evaluate the cooling efficiency of a blower-motor unit in a fixed system but with varying density (during flight, say), it is necessary to determine the performance of the unit at the operating point as a function of density or altitude. The four curves in Fig. 7, plotted for altitudes from sea level to 60,000 ft, have been determined from Figs. 1, 2 and 6 in a manner similar to that for the development of Fig. 5:

Step 1: Calculate required motor torque T_o at the operating point for the original air density ρ_o and speed n_o from Equation 1, where brake horsepower P_{bo} is obtained from the motor performance curves.

For the operating point at Q_o = 120 cfm in Fig. 1, the required motor torque T_o is 41.5 oz-in. (column 4, Fig. 3).

Step 2: Select a number of values of air density ρ corresponding to altitudes in the range of interest, and for each determine computed torque T_c from

$$T_c = \frac{\rho_c T_o}{\rho_o} \left(\frac{n_c}{n_o} \right)^2 \text{ oz-in.} \qquad (5)$$

where ρ_o = 0.0765 lb per cu ft (assuming sea level as a base), ρ_c is the selected density at altitude, and n_c is an arbitrary speed. Determine T_c for two values of speed n_c at each air density. A straight line is again drawn through the two points to give the blower speed-torque characteristic at each density. As discussed previously, this can only be done if the motor speed-torque curve is plotted on log-log paper. The intersections of blower and motor speed-torque characteristics represent actual values of motor speed and torque at each density.

Values of n_c at 5000 and 8000 rpm have been selected in this example so as to give (for each of the five densities in Fig. 6) the two points shown.

Step 3: Calculate flow rate at each air density from

$$Q_a = Q_o \left(\frac{n_a}{n_o} \right) \text{ cfm} \qquad (6)$$

where Q_a and n_a are values of flow rate and speed at the operating point for each density. The value of n_a is obtained on the ordinate where blower and motor speed-torque curves intersect.

Values of n_a are shown along the ordinate in Fig. 6 as n_o, n_1, n_2, n_3, and n_4. It is evident in Fig. 6 that, at ρ_o = 0.0765 lb per cu ft, the operating point has shifted to speed n_a = 6500 rpm (rather than 6100 rpm) and torque T_a = 47 oz-in. (rather than 41.5 oz-in.).

Step 4: Plot flow rates Q_a, calculated in Step 3, and speed, motor power input and current as functions of altitude. Values n, W and I are obtained on the motor characteristic curves for the torques at the intersections of blower and motor speed-torque curves.

Values of Q_a, n, W and I are plotted in Fig. 7 as functions of altitude from sea level to 60,000 ft. Speed, power and current have been determined in Fig. 2 for actual torques T_a at the intersections in Fig. 6.

Values of Q, n, W and I at the operating point in Fig. 5 and at sea level in Fig. 7 are, as they should be, equal within the limits of the graphs.

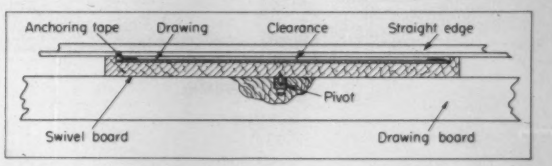
REFERENCES

1. K. A. Merz—"Air Circuit Design," MACHINE DESIGN, Vol. 28, No. 13, June 28, 1956, Page 88.
2. C. A. Hathaway—"How to Select Air Impellers," MACHINE DESIGN, Vol. 28, No. 20, Oct. 4, 1956, Page 88.

Tips and Techniques

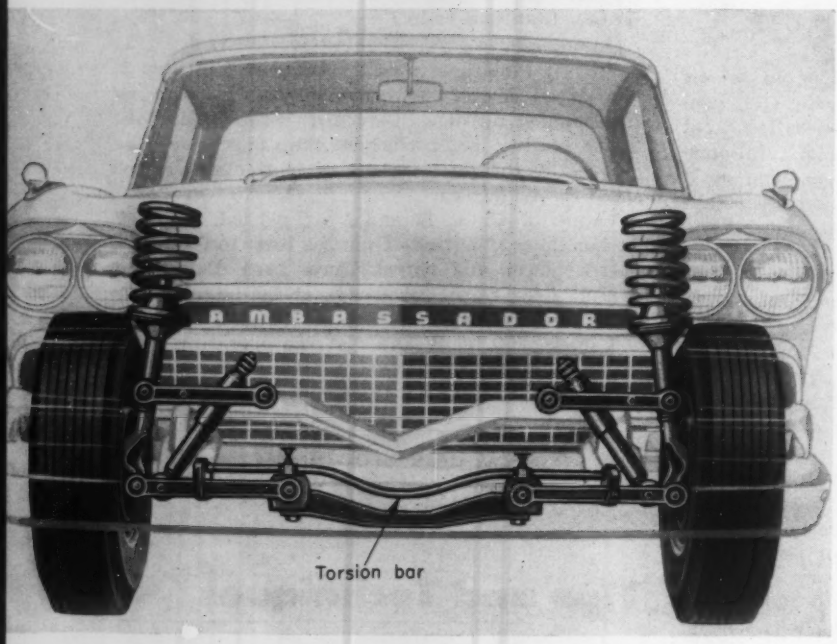
Swiveling Drawing Board

The drawing board shown is very useful for inking-in patent and similar drawings. One feature is that the straightedge can be used for inking-in all straight lines, working horizontally to the drawing without using triangles. Another advantage is that clearance between the straightedge and the



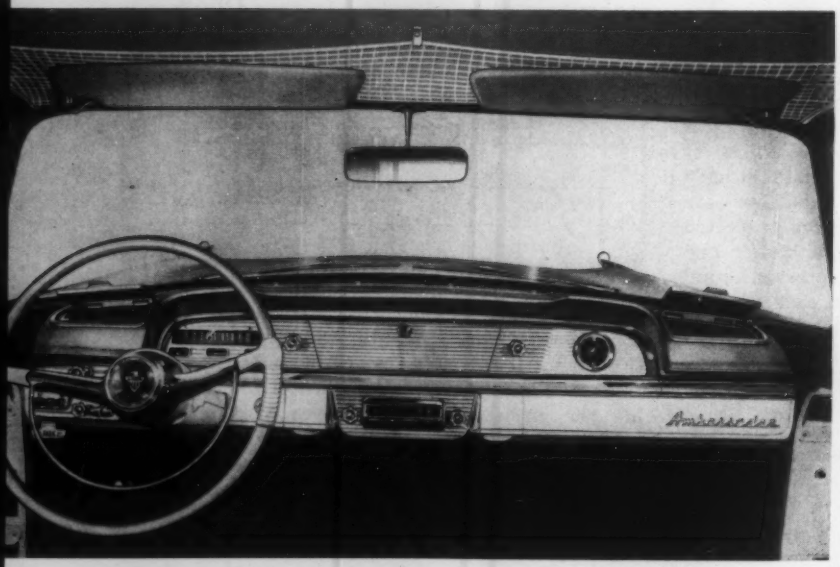
drawing permits free inking without waiting for the ink to dry. This saves a great deal of time and eliminates ink smearing. The board can be rotated with ease about its swivel, yet friction on the supporting drawing board is sufficient to hold the board in any set position. When inking a drawing the circles, arcs and curves are, of course, inked-in before the straight lines. A cross hatching device is easily attached to the straightedge for controlling correct spacing of section lines. With this device, inking-in time can be reduced approximately half.—WALLACE F. GAYRING, *Minoa, N. Y.*

Torsion Bar Restricts Body Roll



Torsion sway-stabilizer bar is a new feature incorporated in the design of 1958 Ambassador cars. A tempered-steel bar is linked between the lower control arms of the front suspension in a manner which restricts body-roll. The bar is mounted in rubber to minimize road-noise transference. The car has deep coil springs on all four wheels, which, coupled with the "sea-leg" shock absorbers, produce a smooth and stable ride. The front coil springs extend into special housings high in the fenders of the machine.

Net across top of windshield on the custom Ambassador models is designed for storing sunglasses, maps, cigarettes, and other items. For greater passenger safety, a full-width crash pad and padded sun visors are standard equipment on custom models.

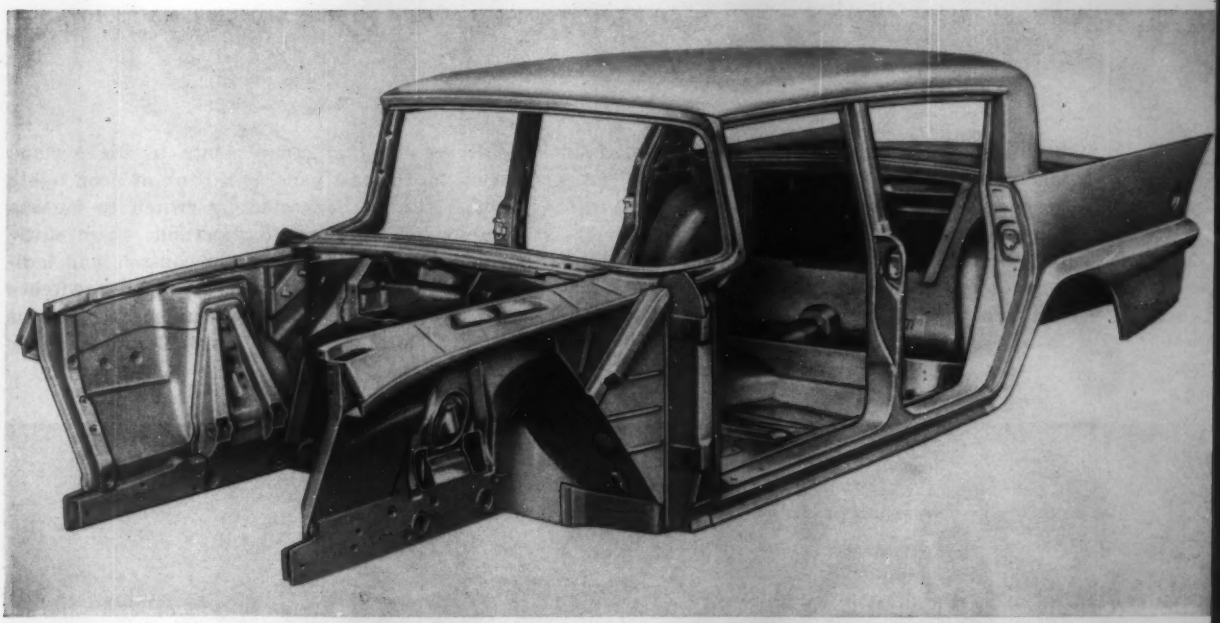


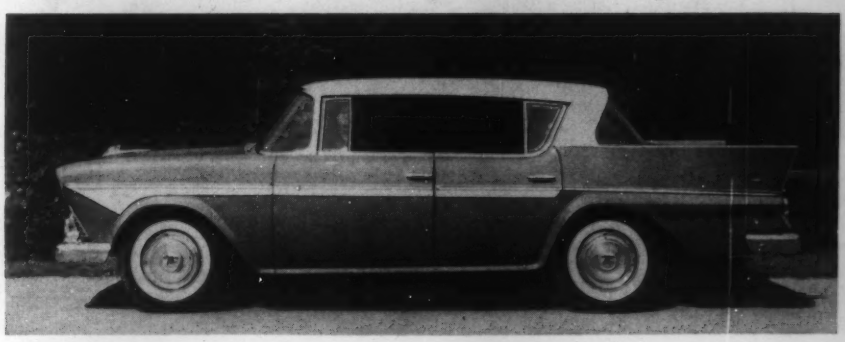
Built-in protection against careless operation is designed into the pushbutton transmission control in the Ambassador. When the "park" control is engaged, all pushbuttons are inoperable. Also, the "park" control can be used only after the neutral button has been pushed in. Reverse button can be engaged only at speeds below 10 mph. Depressing "R" at over 10 mph will shift the transmission to low gear, which will slow the car to 10 mph. The transmission will then shift automatically into reverse operation.

Car Body and Frame Rust-Proofed by Complete Submersion in Primer

To prevent body rust, American Motors uses a "body-dip" process which completely rust-proofs automobile bodies inside and out. Used on the Rambler line, the whole car body is submerged in a large tank containing rust-preventing primer. Thus all sheet metal, including the insides of doors, pillars and other areas inaccessible to spray coating, are protected from rust formation by this dipping process.

Passengers are better protected against front-corner and front-end impacts in accidents because additional steel structural members are built in which extend ahead of the passenger compartment. A protective steel framework runs along each side of the body under the doors to add further protection against side impacts.

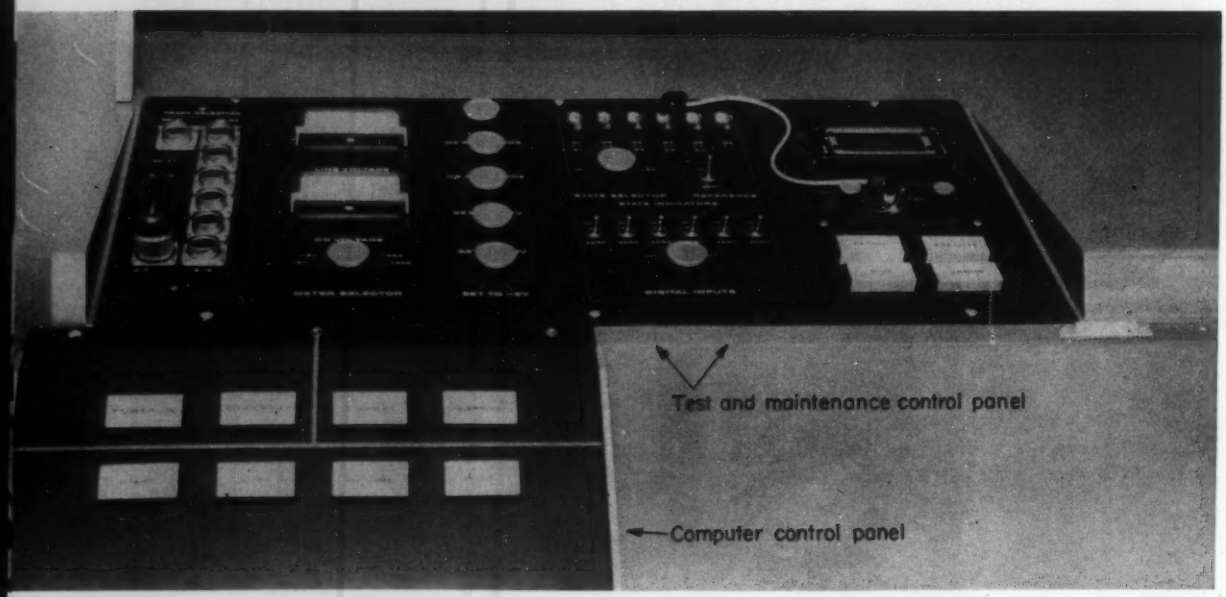




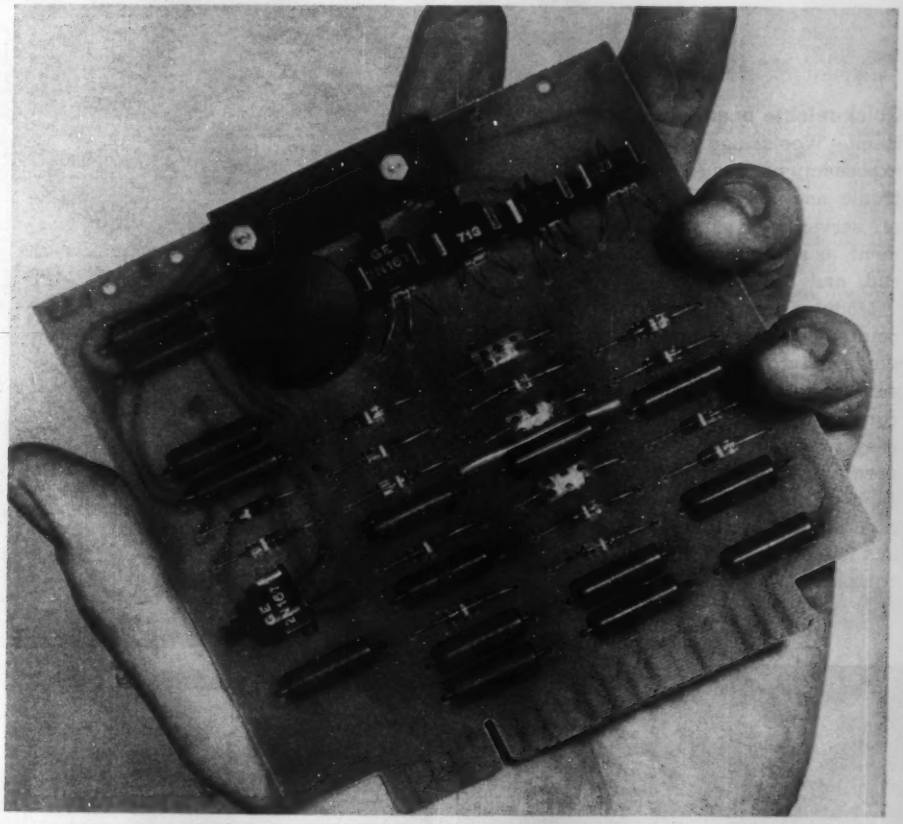
Transistors and Modular Design Make

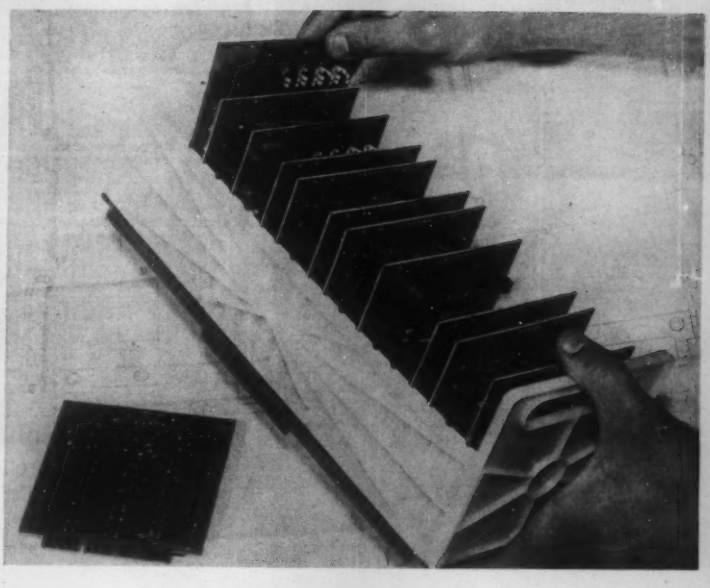
No larger than an office desk, the new Ramo-Wooldridge digital control computer is designed to control manufacturing processes, to log data, to control test operations, and to perform general computations. Known as the RW-300, the computer measures only 55 in. in overall length, is 29 in. wide and 36 in. high, and weighs approximately 400 lb. The machine is designed to permit direct connections to process measuring instruments and control devices. The computer is unique in that input-output, buffering, selection, and analog-digital conversion units have been made integral with the design.

Built-in test equiment in the RW-300 permits manual control of the speed at which the program runs, and facilitates program checkout and computer test and maintenance. Located directly under the computer cover, the test and maintenance unit includes a built-in oscilloscope which can be connected with a multiple-position switch to any of the circulating arithmetic and control registers or other points in the system. Also, on the test panel is a bank of neon lights which can be connected by switch to various groups of flip-flops to determine their static condition. Marginal checking controls and indicators along with program breakpoint switches are provided. Built-in test equipment makes it easy to locate and repair troubles in minutes.



Large-Capacity Computer Desk Size



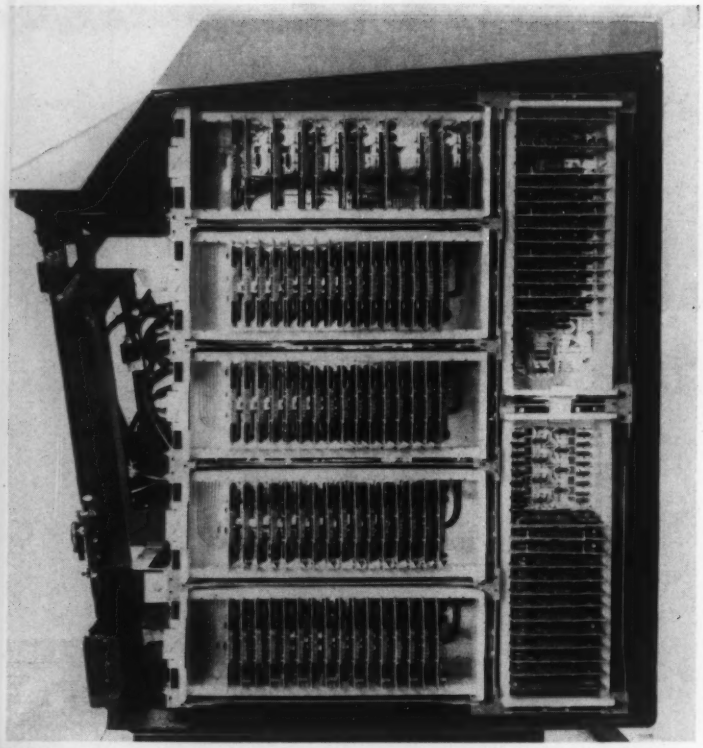


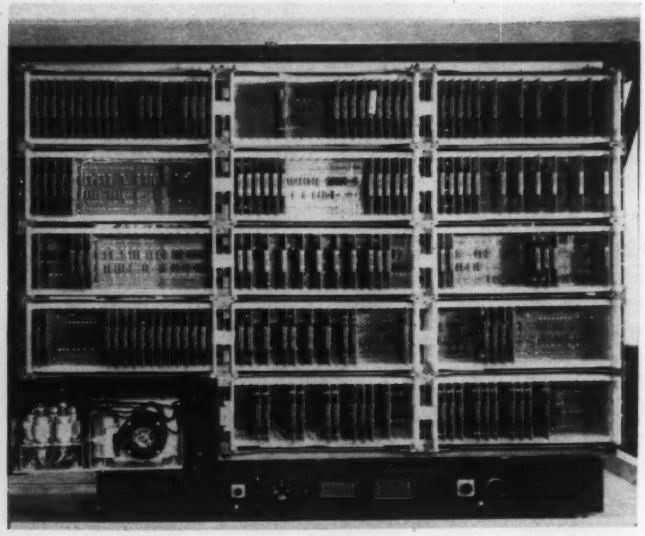
Flush-circuit construction with copper embedded in epoxy resin is used in the design of the computer printed-circuit inserts. This construction provides improved bond strength between copper and resin, making component replacement easier and allowing boards to be handled or stacked without damaging printed circuitry. All active circuits are mounted on inserts, which are in turn attached to modules.

Desk-Size Computer Modular-Design Details

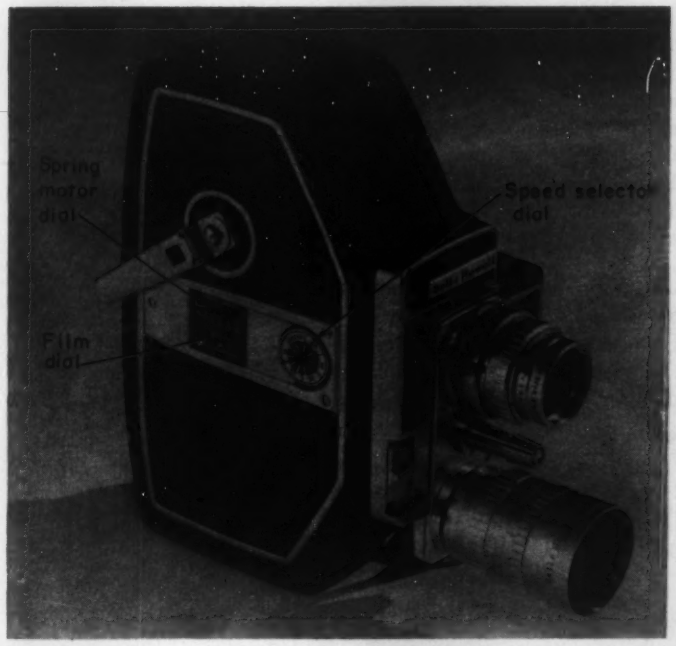
Quick-release panels on the Ramo-Wooldridge computer expose any portion of the electronic assembly for immediate servicing or parts replacement, as shown in these front, end, and back views.

Modules, containing the printed-circuit inserts, are plugged into subframes. The subframes are, in turn, interconnected with cables. The easy-access modular design permits removing and testing each printed-circuit board or a complete module quickly and independently to minimize computer "down time."





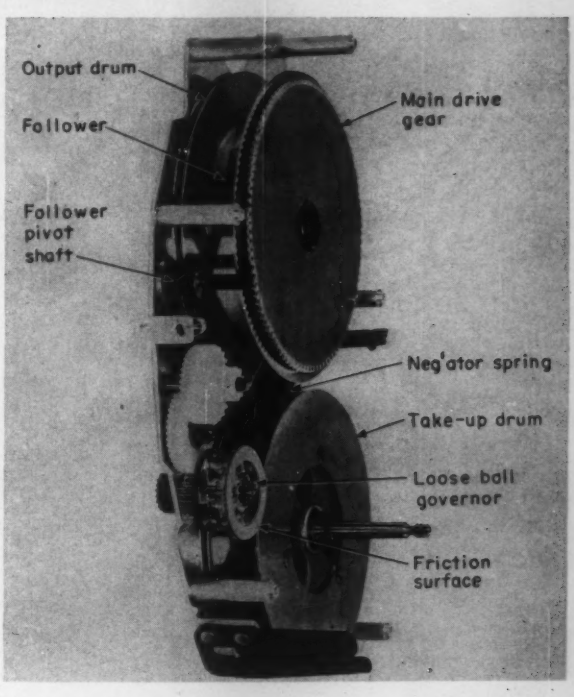
Loose-Ball Governor Regulates Spring-Drive Speed



Film speed is easy to regulate in the new Bell and Howell series 240-T motion-picture camera which uses a Neg'ator spring for a drive motor. The prestressed spring made by the Hunter Spring Co. drives 32 ft of 16-mm film per wind, or about 80 sec of continuous shooting at 16 frames per sec. Little input energy is wasted in regulating the drive speed since spring-motor torque decreases only 20 per cent during the entire output half cycle.

Speed regulation is accomplished with a novel loose-ball governor. In construction the governor consists of four steel balls housed at 90-deg intervals around a cylindrical plastic ball cage. Each ball is free to move radially, under the impetus of centrifugal force, out from the center of the cage. Outward movement of the balls controls the braking action of a friction surface, which is also mounted on the cage. Adjustment of the speed-selector dial positions the balls to control the five different camera speeds.

When the flat-spring drive is fully unwound as shown, a spring-loaded follower engages a notch in the output-drum surface. This action stops output-drum rotation and, through a simple linkage, closes the shutter, eliminating "flash frames." This follower also controls the reading on a dial which shows how much the Neg'ator spring motor is unwound.



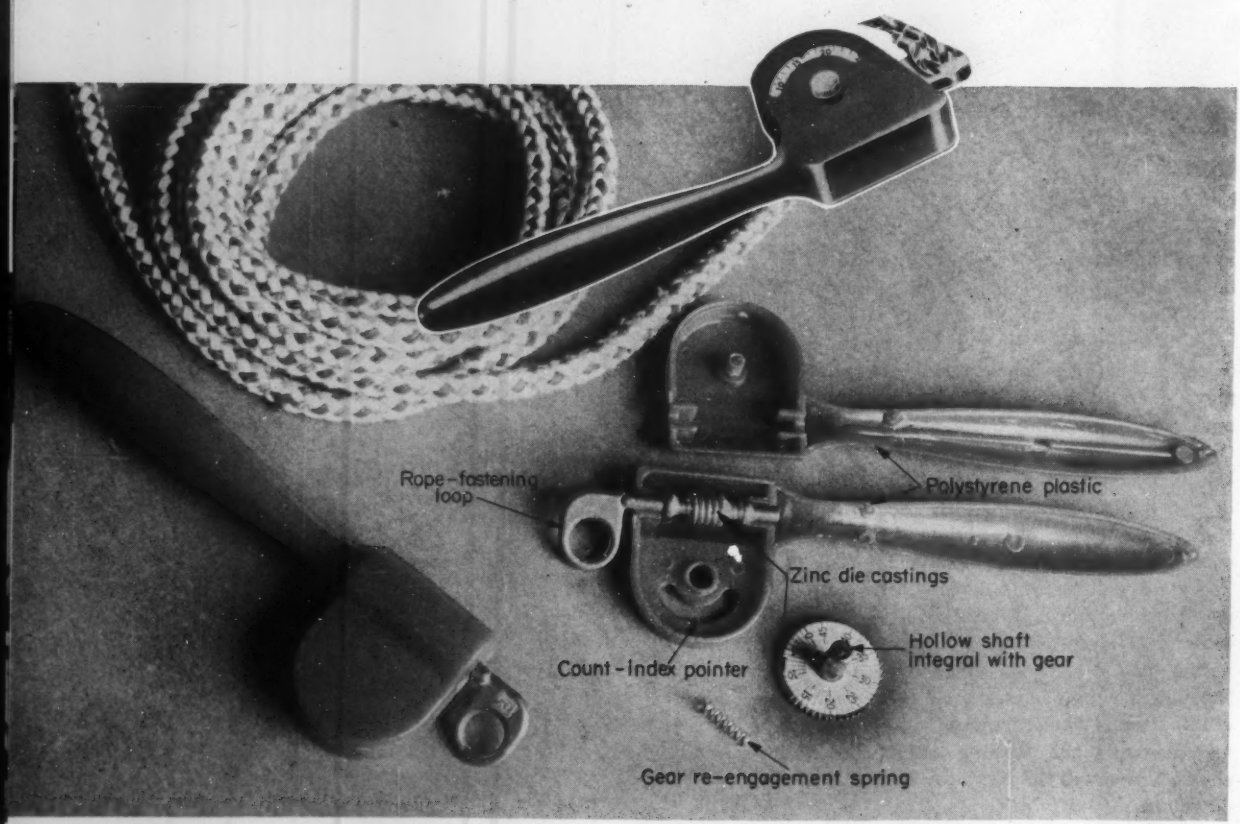
Worm-Driven Gear Is Revolution Counter

In the handle of child's jump rope manufactured by the Pressman Toy Corp. is a counter that automatically records number of skips. To count revolutions properly, the handle containing the built-in counter is held in the right hand for forward skipping and in the left hand for backward skipping. The worm-and-gear assembly has a low gear ratio—for every 48 revolutions of the worm, the gear turns once.

Attached to the gear is a pressure-sensitive label on which a 45-division scale is imprinted. With each revolution of the rope, the worm advances the gear one scale count. A small vee molded into the crescent-shaped window in the handle indexes the count.

The shaft of the gear is hollow with one end, which protrudes through the handle, closed off. To reset counter, this gear protrusion is pushed in, disengaging gear from worm which permits rotating gear back to zero. A compression spring, inside the shaft and resting on the guide-post molded into the lower half of the handle, automatically re-engages gear with worm.

The handle halves are injection molded of high-impact polystyrene plastic. The worm and gear parts are zinc diecastings made by the Gries Reproducer Corp., New Rochelle, N. Y. The same worm design with the integral rope-fastening loop is used in both handles although only one handle has a counter.



Mechanics of Vehicles—10

PERFORMANCE LIMITS

- **performance vs. weight distribution**
- **performance vs. gross weight**
- **engine-torque limits**
- **drive-system comparison**

By JAROSLAV J. TABOREK*
Development Engineer
Towmotor Corp.
Cleveland

MAXIMUM transferable tractive force was shown in Part 9 (Sept. 19, 1957) to set a fundamental limit to vehicle performance, regardless of whether the performance criterion of significance is acceleration, gradability, speed or drawbar pull. Determining factors for maximum tractive force were also shown to be: 1. Available road friction. 2. Effective or dynamic weight on the driving wheels.

This article continues the study of vehicle-performance limits, distinguishing between those performance qualities that are independent of vehicle gross weight and those that are weight dependent. For reference, a roundup of equations for calculating vehicle axle reactions and performance limits (developed in Parts 8 and 9) is given in Table 6.

Weight-Independent Limits: Maximum acceleration and gradability, two performance limits determined by maximum transferable tractive force, are independent of vehicle gross weight. For these qualities, weight distribution alone is the significant condition.

Physical interpretation of this fact is simple. Assume that two vehicles with identical weight distributions but with different gross weights are compared. Obviously, the higher transferable friction force available to the heavier vehicle (because of its greater driving-axle reaction) is exactly balanced by the greater force required to accelerate the vehicle or to push it uphill.

Quite apparently, no gain in tractive-force limited acceleration or gradability is realized when vehicle weight is increased. These performance limits can be improved only by changing vehicle weight distribution, that is, by loading the driving axle with a greater proportion of vehicle gross weight.

Weight-Dependent Limits: Contrary to the case for acceleration and gradability, maximum speed and drawbar-pull are functions of vehicle gross weight. Explanation is that gain in available friction (due to a vehicle weight increase) overbalances the need for a higher tractive force in the heavier vehicle. Consequently, the heavier vehicle can attain a higher speed and can develop a greater drawbar pull.

Tractive-Force Chart: The functional relation-

Nomenclature

a	= Acceleration, ft per sec^2
c_a	= Coefficient of air resistance
D	= Drawbar pull, lb
f	= Coefficient of rolling resistance
g	= Acceleration of gravity, ft per sec^2
H	= Height of cg from ground, in.
H_d	= Height of hitch point, in.
L	= Wheelbase, in.
L_f, L_r	= Distances of cg from front and rear axles, in.
M_d	= Torque on drive axle, lb-ft
M_e	= Engine torque, lb-ft
m	= Mass, lb-sec^2-ft^{-1}
P	= Tractive force, lb
P_f, P_r	= Tractive forces of front and rear-wheel drives, lb
P_{4f}, P_{4r}	= Tractive forces on front and rear-wheel axles of vehicle with four-wheel drive, lb
r	= Rolling radius of tire, ft
V	= Speed, mph
W	= Vehicle weight, lb
W_d	= Dynamic weight, lb
W_{df}, W_{dr}	= Dynamic weights on front and rear axles, lb
W_d	= Dynamic weight transfer in driving, lb
w	= Weight distribution factor
w_f, w_r, w_4	= Weight distribution factors for front, rear and four-wheel drives
ζ	= Reduction ratio
η	= Transmission efficiency, per cent
γ	= Mass factor of rotating parts
μ	= Road-adhesion coefficient

*Now Research and Development Engineer, Phillips Petroleum Co., Bartlesville, Okla.

Table 6 — Axle-Reaction and Performance-Limit Equations

	Front-wheel drive	Rear-wheel drive	Four-wheel drive
Static drive-axle weight, W_f, W_r (lb)	$W_f = W\frac{L_r}{L}$	$W_r = W\frac{L_f}{L}$	$W_f = W\frac{L_r}{L}$ $W_r = W\frac{L_f}{L}$
Dynamic axle-weight transfer, ΔW_d (lb)	$\Delta W_d = \frac{H}{L}(P - fW)$		
Dynamic axle reaction due to tractive force, W_d (lb)	$W_{df} = W_f - \Delta W_d$	$W_{dr} = W_r + \Delta W_d$	$W_{df} = W - \Delta W_d$ $W_{dr} = W + \Delta W_d$
Maximum dynamic axle weight, W_d (lb)	$W_{df} = W\frac{L_r + fH}{L + \mu H}$	$W_{dr} = W\frac{L_f - fH}{L - \mu H}$	$\frac{W_{4f}}{W_{4r}} = \frac{L_r - H(\mu - f)}{L_f + H(\mu - f)}$
Weight-distribution factor, $w = \frac{W_d}{W}$	$w_f = \frac{L_r + fH}{L + \mu H}$	$w_r = \frac{L_f - fH}{L - \mu H}$	$w_4 = 1$
Maximum tractive force transferable, P_{max} (lb)	$P_{f\,max} = w_f \mu W$	$P_{r\,max} = w_r \mu W$	$\frac{P_{4f}}{P_{4f}} = \frac{W_{4f}}{W_{4r}}$
Maximum speed*, W_{max} (mph)	$20\sqrt{\frac{W}{C_o A}(w_f \mu - f)}$	$20\sqrt{\frac{W}{C_o A}(w_r \mu - f)}$	$20\sqrt{\frac{W}{C_o A}(\mu - f)}$
Maximum gradability, G_{max} (percent)	$100(w_f \mu - f)$	$100(w_f \mu - f)$	$100(\mu - f)$
Maximum acceleration*, a_{max} (ft per sec^2)	$\frac{g}{\gamma}(w_f \mu - f)$	$\frac{g}{\gamma}(w_r \mu - f)$	$\frac{g}{\gamma}(\mu - f)$
Maximum drawbar pull*, D_{max} (lb)	$W\frac{\mu L_f - fL}{L + \mu H_d}$	$W\frac{\mu L_r - fL}{L - \mu H_d}$	$W(\mu - f)$

* On level ground

ship between tractive force, road-adhesion coefficient and weight distribution can be plotted in the form shown in Fig. 59. Containing only dimensionless factors, the chart has general validity for all vehicles. Mathematical basis for the chart construction is as follows:

1. Influence of rolling resistance on dynamic axle weight is neglected. This assumption is permissible for concrete or a similar surface where $f = 0.02$ is a common value. The error introduced by omitting f from the weight-distribution equations is about 1 per cent.

2. To make the chart construction independent of the absolute geometrical dimensions of the vehicle, equations for the weight-distribution factor w (Table 6) were rearranged as follows:

FRONT-AXLE DRIVE,

$$w_f = \frac{\frac{L_r}{L}}{1 + \frac{\mu H}{L}} \qquad (175)$$

REAR AXLE DRIVE,

$$w_r = \frac{\frac{L_f}{L}}{1 - \frac{\mu H}{L}} \qquad (176)$$

Values appearing in Equations 175 and 176 are dimensionless ratios L_r/L, L_f/L, and H/L.

3. Weight of the vehicle is eliminated by dividing the tractive-force equation (Table 6) by W, giving

$$\frac{P_{max}}{W} = w\mu \qquad (177)$$

The dimensionless quantity P_{max}/W represents the tractive force per unit of vehicle weight (lb per lb).

4. The effective tractive force on the driving wheels is a product of various combinations of the following elements: engine torque M_e, transmission reduction ratio ζ, efficiency of the reduction mechanism η and rolling radius of the tires r. Consequently, a value of maximum engine torque per unit vehicle weight can be found, where

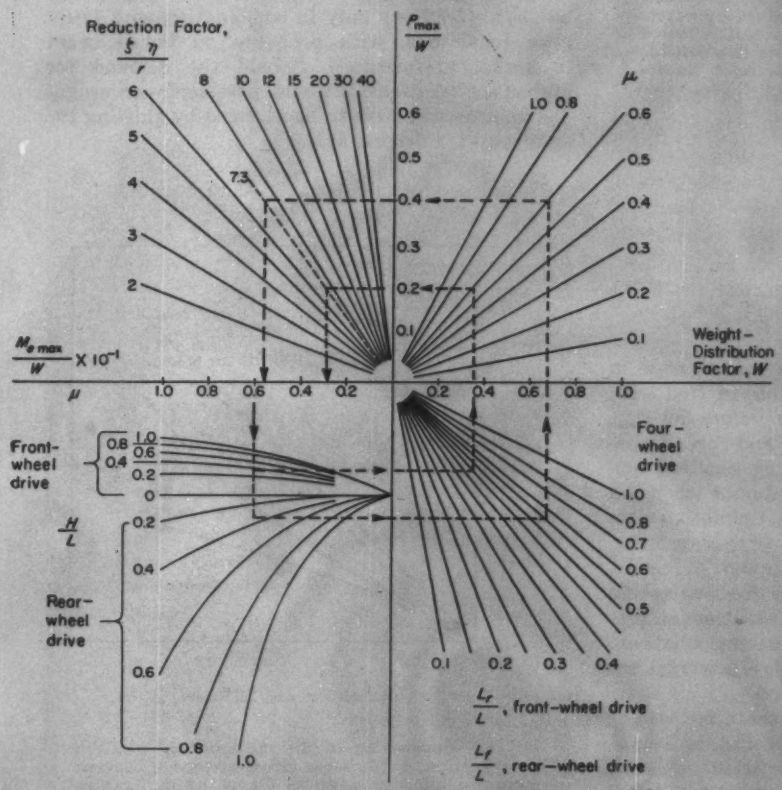


Fig. 59—Graphical relationship between the road-adhesion coefficient μ, the vehicle weight distribution, given by the factors H/L, L_r/L, L_f/L, and the specific values of maximum transferable traction P_{max}/W and corresponding engine torque M_{emax}/W. Only dimensionless quantities are plotted, and the chart is therefore applicable to all vehicles.

Example: A vehicle has cg position $H/L = 0.35$, $L_f/L = 0.55$, and $L_r/L = 0.45$. Maximum transferable traction on dry concrete ($\mu = 0.60$) for both front and rear-wheel drives is required. Maximum engine torque for a low-gear reduction factor $\zeta\eta/r = 7.3$ (ft^{-1}) is also desired.

Solution: In the lower left quadrant, the $\mu = 0.60$ ordinate is projected to intersect the H/L curves at a value of 0.35. From the intersection, the heavy example lines are followed, giving $P_{fmax} = (0.21)(W)$ and $P_{rmax} = (0.405)(W)$ as the values for maximum transferable traction.

When the example lines are then followed to the left-hand abscissa axis, maximum engine torques are: $M_{emax} = (0.056)(W)$ for the front-wheel drive, and $M_{emax} = (0.028)(W)$ for the rear-wheel drive.

Assuming vehicle weight is 4000 lb: $P_{max} = 1620$ lb and $M_{emax} = 224$ lb-ft for the rear wheel drive; and $P_{max} = 840$ lb and $M_{emax} = 112$ lb-ft for the front-wheel drive.

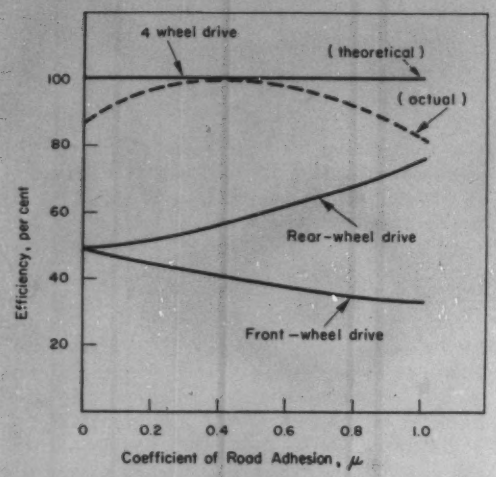


Fig. 60—Efficiency of front, rear and four-wheel drive systems as functions of the road-adhesion coefficient. Diagram represents the weight-distribution factor in per cent ($w \times 100$) for a car with identical weight on front and rear axles. Front and rear-wheel drives have the same efficiency at low friction values. With increasing friction, the rear-wheel drive arrangement becomes more efficient and front-wheel drive efficiency decreases. Effectiveness of the four-wheel drive is maintained at the theoretical 100 per cent value throughout the range of frictional adhesion only if torque distribution to the axles is adjustable for varying μ values. Actual performance reaches the theoretical maximum only at that frictional value for which the drive is calculated.

$$\frac{M_{emax}}{W} = \frac{\frac{P_{max}}{W}}{\frac{\zeta\eta}{r}} \qquad (178)$$

These equations are graphically represented in Fig. 59. The chart makes it possible to find with ease and acceptable accuracy the values of P_{max} and M_{emax} for any vehicle weight and for all possible combinations of wheelbase, cg position and road-adhesion coefficient. The technique of using the diagram is illustrated by the example shown with the figure.

Practical Engine-Torque Limits: An interesting example of performance-limits calculation is presented by the often repeated question: what are the limits of the trend toward more powerful engines on passenger cars?

As a basis for analysis, a representative weight distribution (loaded car) of $L_f = 0.55L$, cg height $H = 0.35L$ and road-adhesion coefficient $\mu = 0.6$ are assumed. For these values and for the usual rear-wheel drive, Fig. 59 gives $P_{max} = 0.4W$. Maximum possible acceleration, one of the main criteria for judging performance of a passenger car, is unalterably given by the cg position. Value of a_{max} is calculated directly from the P_{max} value by use of the relation

$$a_{max} = \frac{Pg}{W\gamma} \qquad (179)$$

In this example, the rotating-parts inertia factor in direct gear is assumed to be $\gamma = 1.1$. Therefore,

$$a_{max} = \frac{(0.4)(g)}{1.1} = 0.36g = 11.5 \text{ ft per sec}^2 \qquad (180)$$

Assume further that the tractive force is produced through a total reduction ratio of 9.5:1 in low gear (common usage on passenger cars), an overall transmission efficiency of 85 per cent and a rolling radius of the tires of $r = 1.1$ ft. Then

$$\frac{\zeta\eta}{r} = \frac{(9.5)(0.85)}{1.1} = 7.3 \qquad (181)$$

For this value, the diagram gives $M_e/W = 0.056$ and, for an assumed vehicle gross weight of 4000 lb, the maximum engine torque that can be transferred by use of the 9.5:1 reduction ratio is

$$M_{emax} = (4000)(0.056) = 224 \text{ lb-ft} \qquad (182)$$

Passenger-car engine torques in the 200 lb-ft range are now becoming common. Apparently, then, the drive-wheel frictional limits in low gear have been nearly reached. Higher engine torques can be used effectively only in combination with lower gear reductions, with probably no improvement in actual performance. Should the demand for higher accelerations continue, passenger-car weight distribution will have to be changed by shifting the cg toward the driving axle.

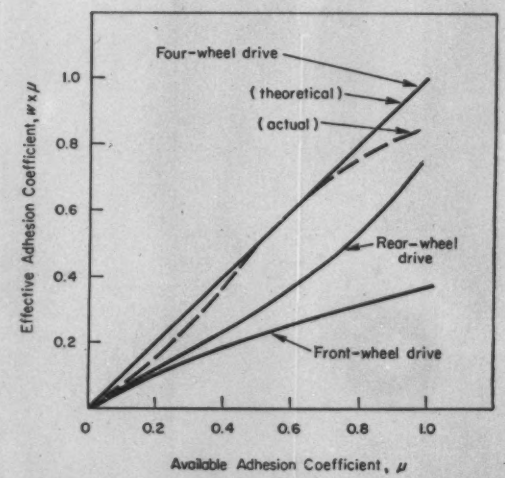


Fig. 61—Comparison of the utilization of available road friction by different drive systems. Diagram represents effective μ values ($w \times \mu$) as functions of available μ values. The four-wheel drive reaches the theoretical 100 per cent utilization only for the value of μ for which torque distribution to the axles corresponds to the theoretically required condition. Difference in friction utilization between front and rear-wheel drives increases with higher friction values.

Drive-System Comparison: Theoretical performance limits are not always reached because, with high values of road friction, engine power is often the determining factor. Obviously, in such cases, dynamic weight distribution is of no importance where the tractive performance of the vehicle is concerned. On the other hand, where high tractive-force values are a necessity, or where the vehicle must operate under poor frictional conditions, weight distribution does become a critical factor, and the performance differences between front, rear and four-wheel drive systems become apparent.

A fair measure for comparing effectiveness of the three drive-systems is the degree to which they utilize the available friction. Such a comparison is given by the ratios

$$P_4 : P_r = \mu : \mu \frac{\frac{L_f}{L}}{1 - \frac{\mu H}{L}}$$

$$P_r : P_f = \mu \frac{\frac{L_f}{L}}{1 - \frac{\mu H}{L}} : \mu \frac{\frac{L_r}{L}}{1 + \frac{\mu H}{L}} \qquad (183)$$

Or, in combined form

$$P_4 : P_r : P_f = \mu : \mu \frac{\frac{L_f}{L}}{1 - \frac{\mu H}{L}} : \mu \frac{\frac{L_r}{L}}{1 + \frac{\mu H}{L}} \qquad (184)$$

The right side of this expression represents ratios of the effective friction coefficients utilized by the three drive systems. These values are plotted against the available road-adhesion coefficient μ in Fig. 60 for an assumed vehicle static weight distribution corresponding to $L_r = L_f = 0.5L$, and $H = 0.35L$.

At any point, the four-wheel drive offers the theoretical maximum of effectiveness, that is 100 per cent. Efficiencies of front and rear-wheel drive systems, calculated as function of the available road-adhesion coefficient, are also shown in Fig. 60. With increasing friction values, efficiency of the rear-wheel drive also increases. In contrast, front-wheel drive efficiency declines. For the usual road-adhesion coefficient of $\mu = 0.6$, ratios of maximum transferable tractive forces for the three drives are

$$P_4 : P_r : P_f = 100 : 61 : 39$$

The same proportion applies for maximum engine torques usable by each particular drive type.

The potential usability of the different drive systems can be deduced from the foregoing comparison. Front-wheel drives can support only light engines and will therefore find use only on lightweight cars. In such applications, the superior curve behavior, increased interior roominess and compact power plant construction provided by the front-wheel system are important advantages.

The rear-wheel drive accounts for a majority of present-day designs and, most probably, will maintain its leading position. However, the trend toward the use of heavier and more powerful passenger-car engines has resulted in a steady weight shift to the front axle. Aside from other disadvantages offered by heavier engines, the trend directly opposes the urgent need for more frictional weight on the driving rear axle, a requirement that permits the axle to transfer high torques made available by more powerful engines. An improvement in this situation can be achieved by locating the engine in the rear of the car. Used in several highly successful designs, rear-engine location is likely to find increasing use in the future.

Advantages of the four-wheel drive are more pronounced when friction values are low. The higher manufacturing cost of a four-wheel drive vehicle is therefore justified, only if maximum possible traction is the objective, or if the vehicle is designed to operate under poor frictional conditions. Off-the-road or military vehicles offer examples of such applications. Should the trend toward more powerful engines continue, the four-wheel drive may also provide a practicable design solution.

Mechanics of Vehicles

In "Limits of Vehicle Performance", Part 9 of the Mechanics of Vehicles series by Jaroslav J. Taborek, Sept. 19 issue, pp. 152 to 156, Equations 170 and 172 were incorrectly presented. Following are the correct forms.

$$D_{max} = W \left[\frac{(\mu L_r - fL)}{L + \mu H_d} - \frac{(L + \mu H)\sin(\pm\theta)}{L + \mu H_d} \right] \qquad (170)$$

$$D_{max} = W \left[\frac{(\mu L_f - fL)}{L - \mu H_d} - \frac{(L - \mu H)\sin(\pm\theta)}{L - \mu H_d} \right] \qquad (172)$$

They Say . . .

"Engineering, then, is a science, committed to scientific methodology and to interpretation of phenomena in terms of physical laws derived through scientific observation and inference. In fact, if the basic physical sciences have not established the physical laws or confirmed theories regarding the phenomena involved in engineering products or machines, it is the responsibility of engineering science to utilize the methods and facilities of the basic sciences in order to obtain the knowledge needed. Otherwise, there is grave danger of reverting to unconfirmed speculation or empirical practices that are not supported by the results of scientific experimentation. In essence, these are types of magic, alien to the scientific discipline."—E. R. JERVIS, *Aeronautical Radio Inc., Washington, D. C.*

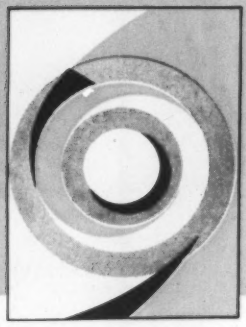
How to design

High-Speed Rotating Parts

for maximum "burst-resistance"

This article presents a basic discussion of (1) the nature of centrifugal loading and (2) the influence of stress, strength and ductility upon bursting speed. Although based principally on extensive testing of aluminum components, it is a general but fundamental guide to design for most effective utilization of materials in rotating parts.

By R. G. ANDERSON
Chief Test Engineer, Development Div.
Aluminum Company of America, Cleveland

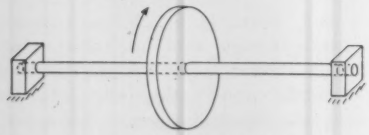


INCREASED use of high-speed rotating parts requires increased knowledge of the effect of design criteria on performance and the properties of the material used in construction. Alcoa's interest in the testing and design of such parts was accelerated after 1944 by the construction of a spin pit for stress analysis and the testing of rotating parts. Since then, approximately 200 different projects have been completed. The parts investigated ranged in weight from less than 1 lb to over 1600 lb. Diameter of these parts ranged up to 60 in. Speeds have been reached as high as 70,000 rpm and parts have been spun without rupture with peripheral velocities up to 3000 fps. Fig. 1 shows some of these parts.

Tests have been conducted with emphasis on structural and economic suitability consistent with performance and safety, rather than the investigation of aerodynamics or the hydraulic aspects of the design. No attempt has been made to simulate vibratory or thermal characteristics since these phenomena should be determined from full-scale testing in actual installations.

Materials: Most of these investigations have been conducted with aluminum alloys fabricated by: Sand casting, permanent-mold casting, semipermanent-mold casting, plaster casting, die casting, forging, aluminum-brazed construction, and premium-strength casting. A premium-strength casting may be defined as a casting made by a process in which the best techniques have been engineered to a particular casting geometry during fabrication to produce a high-quality product having exceptionally uniform, high mechanical properties. It may utilize any conventional or combination of

Table 1—Comparison of Aluminum and Steel Discs



OD = 12 in., ID = 2 in.

	Aluminum 2014-T6	Steel 4130
Tensile strength	65,000 psi (1*X*)	180,000 psi (2.8*X*)
Hardness	130 bhn	Rockwell 40 C
Burst speed	40,000 rpm	40,000 rpm
Weight	1*X*	2.8*X*
Deformation at speed (elastic)	1*X*	1*X*
Energy at speed	1*X*	2.8*X*
Critical speed (idealized)	1*X*	0.6*X*
Gyroscopic effect	1*X*	2.8*X*

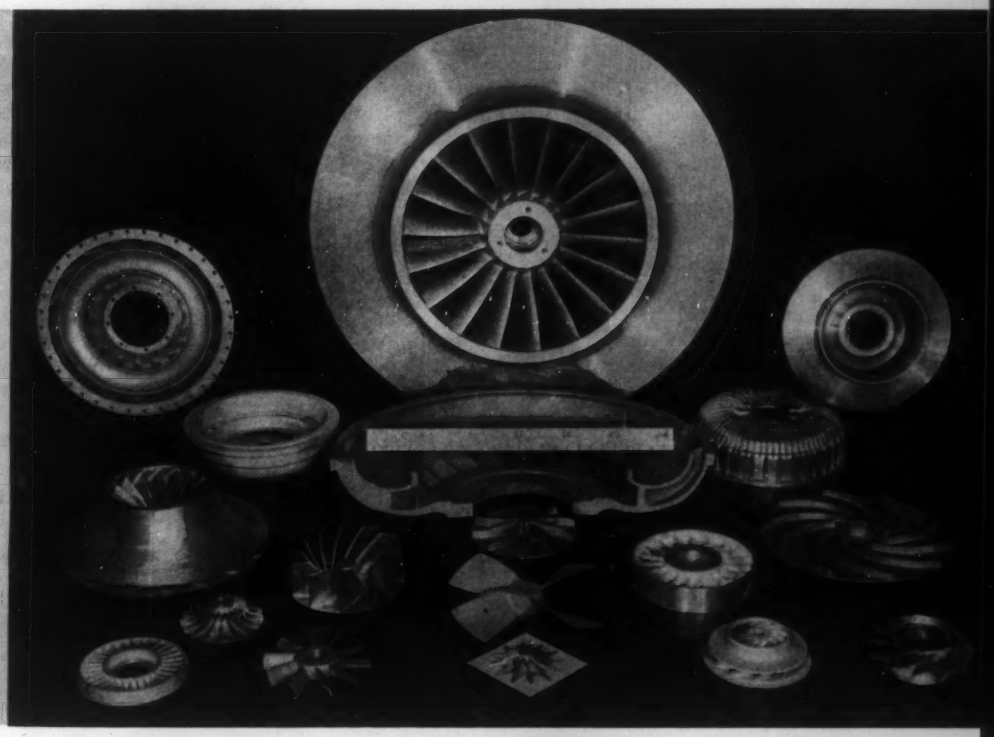


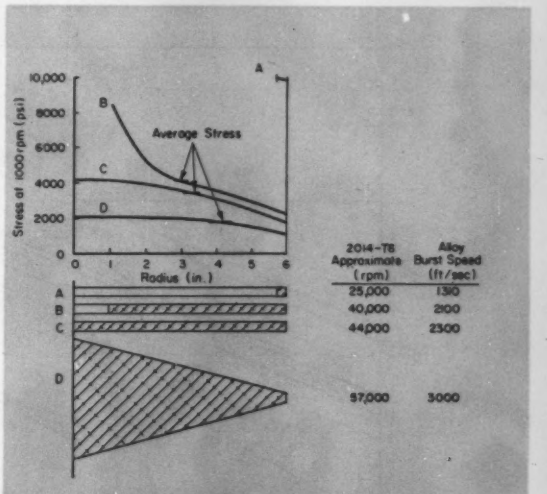
Fig. 1—Typical aluminum high-speed rotating parts fabricated by sand, permanent-mold, semipermanent - mold, plaster and die casting, furnace brazing, forging and pressing. Some of these parts operate at 70,000 rpm.

conventional processes. Advantage has been taken to improve properties by heat treatment wherever applicable.

Aluminum is well suited for many high-speed rotating parts where the service conditions are within the temperature characteristics of the metal. The chief reason is, of course, low density. Other reasons may be corrosion resistance, easy machining, and the many methods of fabrication and joining available for economic production of the part.

Density and Speed Effects: Magnitude of the stresses set up by inertia in a rotating part of a given shape is directly proportional to the density of the material. Benefits derived from the lower density of aluminum are shown in Table 1 where a comparison is made between uniformly thick discs of aluminum and steel. Test results indicate that for a bursting speed of 40,000 rpm in 2014-T6 aluminum alloy, a steel having 180,000 psi tensile strength is required. The greater density of the steel is counteracted by its higher modulus of elasticity, resulting in the two discs having almost identical deformations throughout the speed range as long as stresses are within the respective elastic ranges.

A comparison of rotational energy is of interest because the lower it is, the more responsive the machine will be to acceleration or deceleration. However, if a flywheel or gyroscopic effect is desired, a material having a higher density may be desirable. It may be of interest to consider that the steel disc shown in Table 1, if 1 in. thick and rotating at 40,000 rpm, would contain approximately 1,000,000 lb-ft of energy. This is equal to



	2014-T6 Approximate (rpm)	Alloy Burst Speed (ft/sec)
A	25,000	1310
B	40,000	2100
C	44,000	2300
D	57,000	3000

Fig. 2—Tangential stress in rotating aluminum parts of simple cross sections.

the potential for destruction of a 3500 lb automobile traveling at 60 mph.

Should a part fail due to overspeeding, poor design, or material defect, the damage created is in direct proportion to the rotational energy within the rotating part. This could be an important consideration under conditions where the surrounding housing must have ample strength to contain the part if it bursts.

The benefits of a higher critical speed and lower gyroscopic effect both tend to lighten bearing loads, allow lighter supporting structure, and provide smoother operation.

The major load in most high-speed rotating parts results from the inertia of the material from which the part is produced. Table 2 gives data for a simple illustration which may contribute to the understanding of the source of the load. Here is shown a 1-in. cube of aluminum rotating at a 6-in. radius, and the force required in the cable to hold the cube of aluminum in its path. In an actual rotating part, the forces or stresses would be those existing in the inner portions created by the material near the periphery. This force is the product of mass and acceleration.

As can be seen, a speed of only 76 rpm sets up forces equal to the normal weight of the cube or, in other words, the radial force is equal to the weight of the cube. As speed of rotation is increased, the force in the cable increases rapidly. At 5000 rpm, a velocity of 261 fps is reached. Under these conditions, this could constitute a "high-speed" part in certain products. A top speed of 1050 fps is reached at a speed of 20,000 rpm, which is in the range of speed of many supercharger impellers. Aluminum parts have been tested without rupture at a speed of 57,000 rpm, which is equal to a peripheral velocity of 3000 fps.

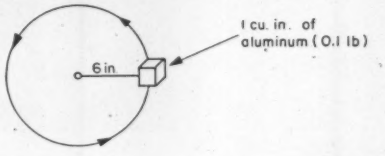
Shape Effects: The stress distribution of some simple shapes rotating at a speed of 10,000 rpm is shown in Fig. 2. Section A is essentially a hoop. During spinning, the cross section is subjected to an approximately uniform tensile stress.

In Section B, metal has been added to create a uniformly thick disc with a central hole. The added metal contributes substantially to the strength of the part because of the metal near the center but, unfortunately, a stress concentrator results at the central hole. This can be seen from the wide range in stress across the section.

With the central hole filled with metal, Section C, the peak stress has been reduced about 50 per cent in relation to the disc with the central hole. Also, the peak stress is only slightly greater than the average stress for the section.

In Section D, which is a more ideal rotating

Table 2—Effect of Speed upon Rotating Parts



Rotational Speed (rpm)	Linear Speed (ft/sec)	Centrifugal Force (lb)
76	4—Normal walking pace	0.1—Its own weight
1,000	52—City driving	17—One-year old baby
5,000	261—Cruising airliner	427—55-gal drum of gasoline
20,000	1050—Almost speed of sound	6,840—Cadillac, loaded
57,000	3000—Muzzle velocity of hunting rifle	56,000—16 Fords
76,000	4000—Cleveland to Pittsburgh in 2½ minutes	1000,000—Capacity of certain railroad freight cars, or an 8-ft aluminum cube

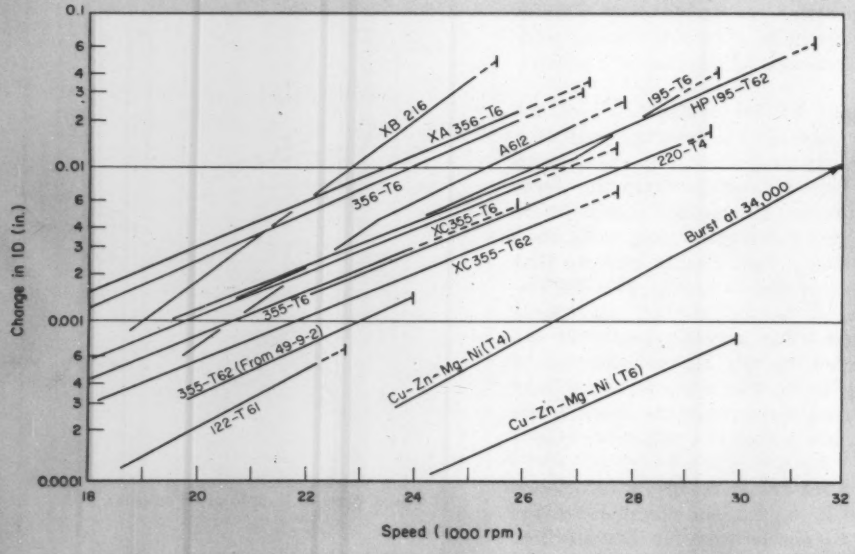


Fig. 3—Permanent set in ID of 12-in. OD by 2-in. ID by ½ in. thick sand-cast discs after 5-second spin at different speeds. End of solid line is last measurement; vertical line denotes burst.

shape, the stress closely approaches a uniform distribution. It is possible by using a hyperbolic profile to obtain a nearly perfect stress distribution.

Plastic Behavior: With increasing speed of a rotating part, a speed is reached where a stress at some location is above the yield strength of the material, provided the material has some degree of ductility. Some information on the yielding of material can be obtained from Fig. 3. This graph is the result obtained from many discs of Section B which have been speeded into the plastic range. The abscissa is the speed on a linear scale, while the ordinate is the permanent increase in a 2-in. diameter central hole plotted logarithmically.

Attention is called to the fact that this is the change after spinning to the speed indicated. To avoid confusion, points are not shown on these curves but the variations were small and considered within the limits of measuring error. The upper end of the solid line indicates the speed at which the last measurement was taken. This line has been extrapolated by means of a dotted line to the vertical mark where failure took place.

An interesting feature of this illustration is that the relations are linear, indicating that the log of the permanent change is directly proportional to the speed. Also, the slopes for different materials are very similar, with the exception of two alloys containing appreciable amounts of zinc and magnesium. The reason for such relationships is not clearly understood, although it has been observed repeatedly in both cast and wrought aluminum alloys in both simple and complex shapes. In general, the wrought alloys burst at a higher speed than the cast alloys.

Fig. 4 shows a cross plot of the results illustrated in Fig. 3. The abscissa is the yield strength of the material at 0.2 per cent offset, and the ordinate is the computed strength at which a certain amount of permanent change in ID takes place. Two stress ordinates are shown, one being the average stress for the cross section of the disc and the other the theoretical elastic stress indicated by the permanent change in OD. Note that the theoretical elastic stress is 1½ times the yield strength with an increase in ID of 0.1 per cent. For an increase of 0.5 per cent (plastic action), the theoretical stress is twice the yield strength of the material. The reason for these factors is that the disc is only partially plastic at these speeds and, upon slowing down, the material that was elastic at speed exerts an inward pressure on the material that had become plastic.

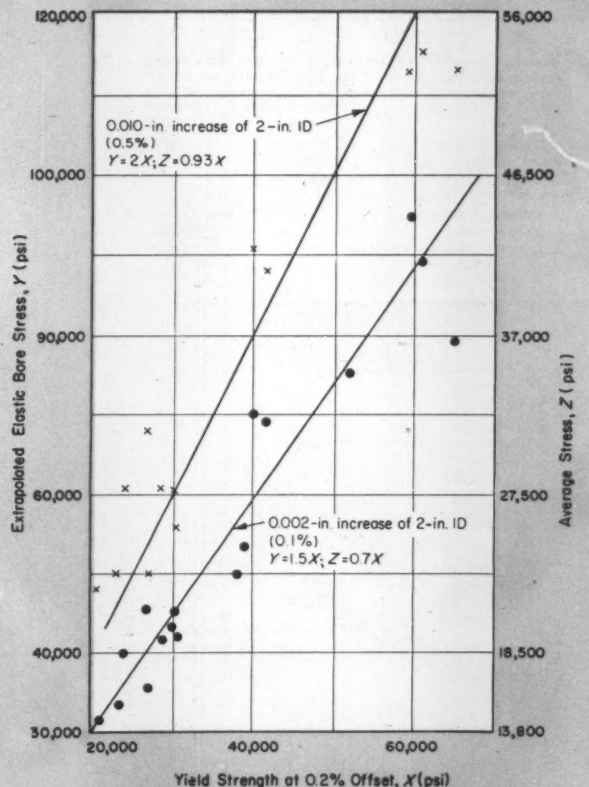


Fig. 4—Cross plot of Fig. 3 data, for two increments of increase in disc ID.

Bursting Speed: One of the questions that may be uppermost in a designer's mind is that of determining the speed at which a rotating part will rupture. The three major factors influencing the

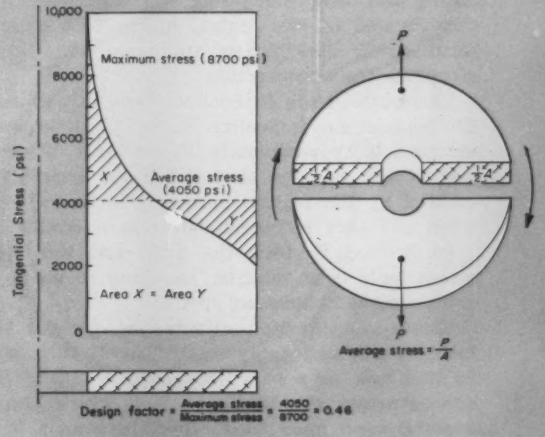


Fig. 5—Meaning of "average stress" and "design factor." Data are for an aluminum disc, 12-in. OD by 2-in. ID, rotating at 10,000 rpm.

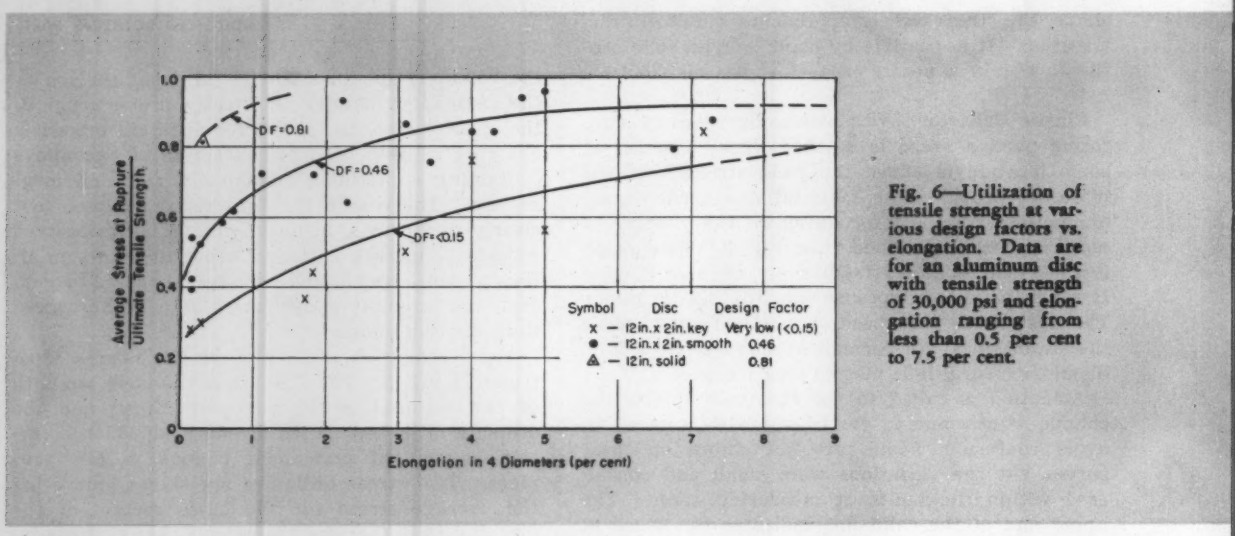

Average Stress at Rupture / Ultimate Tensile Strength
DF=0.81
DF=0.46
DF=<0.15
Symbol Disc Design Factor
x — 12 in. x 2 in. key Very low (<0.15)
● — 12 in. x 2 in. smooth 0.46
△ — 12 in. solid 0.81
Elongation in 4 Diameters (per cent)

Fig. 6—Utilization of tensile strength at various design factors vs. elongation. Data are for an aluminum disc with tensile strength of 30,000 psi and elongation ranging from less than 0.5 per cent to 7.5 per cent.

bursting speed of a rotating part are stress, tensile strength, and ductility. These factors do not in themselves answer the question, as the geometry of the part can set up significantly different stress systems.

Referring again to Fig. 2, Section A is nothing but an endless test bar under approximately uniform stress. It has a simple stress system, and will fail by rupture when the stress in the ring reaches the tensile strength of the material, regardless of ductility. If this ring had been fabricated from 2014-T6 alloy, the burst would take place at approximately 25,000 rpm.

With Section B, the peak stress is located at the inside diameter and, although 13 per cent lower than the stress in the ring, the burst speed becomes 40,000 rpm. This is because of the ductile material which can yield, creating a new distribution of stress and thus mitigating the stress concentration created by the central hole. This more uniform stress distribution approaches the average stress for the cross section.

The peak stress in Section C is 48 per cent of the peak stress in Section B, but the improvement in speed is approximately 10 per cent. From this test, it can be seen that the stress concentration created by the central hole is of little importance when the part is fabricated from a ductile alloy.

In Section D, both the peak and the average stress have been reached, resulting in an appreciable increase in bursting speed.

Stress-concentration effects are general in rotating parts and apply regardless of their source, be it a hole or a sharp corner in a fillet. Stress concentrators should be avoided where they are superimposed upon each other, such as a keyway in a central hole.

Design Factors: It has been shown that in the thin ring and the hyperbolic contoured discs, although bursting takes place at widely different speeds, rupture takes place when the average stress reaches the tensile strength of the material. Thus, a design or utilization factor of 1 can be assigned to both Sections A and D.

At the present state of development, it is intended that design factors, with sources limited to simple shapes, be used to indicate trends and to show the interrelationship of the design of the

Table 3—Effect of Forging on Strength
(Aluminum disc—12 in. OD by 2 in. ID by ¾ in. thick)

	Sawed from Ingot	Properly Forged
Ultimate strength (psi)	66,000	70,000
Yield strength (psi)	62,000	62,000
Elongation (per cent)	less than 2	10
Burst speed (rpm)		
Smooth bore	23,000	over 41,000
Keyed bore	14,000	31,000
Strength reduction (Factor of keyway)	2.9	1.7+

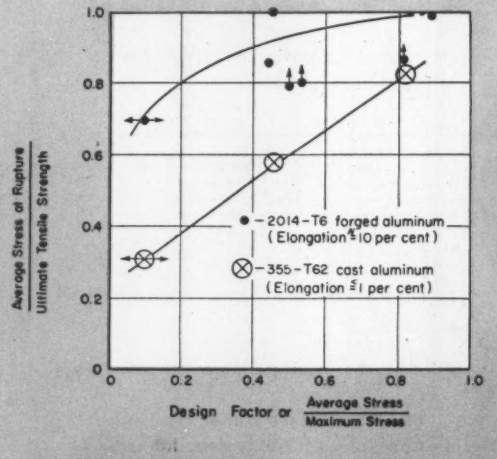

Average Stress at Rupture / Ultimate Tensile Strength
● — 2014-T6 forged aluminum (Elongation ≥ 10 per cent)
⊗ — 355-T62 cast aluminum (Elongation ≤ 1 per cent)
Design Factor or Average Stress / Maximum Stress

Fig. 7—Effect of design factor on the utilization of tensile strength

part and of the material.

The meaning of average stress and design factors is shown by Fig. 5. The disc illustrated is the same disc shown as Section B in Fig. 2. This figure shows the tangential stress distribution along the radius of this simple disc. For a speed of 10,000 rpm, the peak stress is 8700 psi. The illustration on the right in Fig. 5 represents the forces on two halves of the body tending to pull it apart across a diametral section and is comparatively easy to compute. With perfect plastic action, it represents the least stress that can exist in the part. Superimposing the elastic stress distribution curve on the average stress line for a given speed, produces two equal areas, *X* and *Y*. Dividing the average stress by the peak stress gives the design factor for the part. A design factor of 1 would indicate full utilization of the tensile strength of the material or a part that is uniformly stressed across the diametral section. A low design factor may give a part whose bursting speed is greatly affected by ductility.

Fig. 6 illustrates the effect of elongation of the material on the utilization of the tensile strength at various design factors. The solid disc, having a design factor of 0.81, although fabricated from a material having a low elongation, utilizes over 80 per cent of the tensile strength of the material. With a design factor of 0.46, material having low ductility allows only about 40 per cent utilization of the tensile strength. This utilization factor increases rapidly and 80 per cent of the tensile

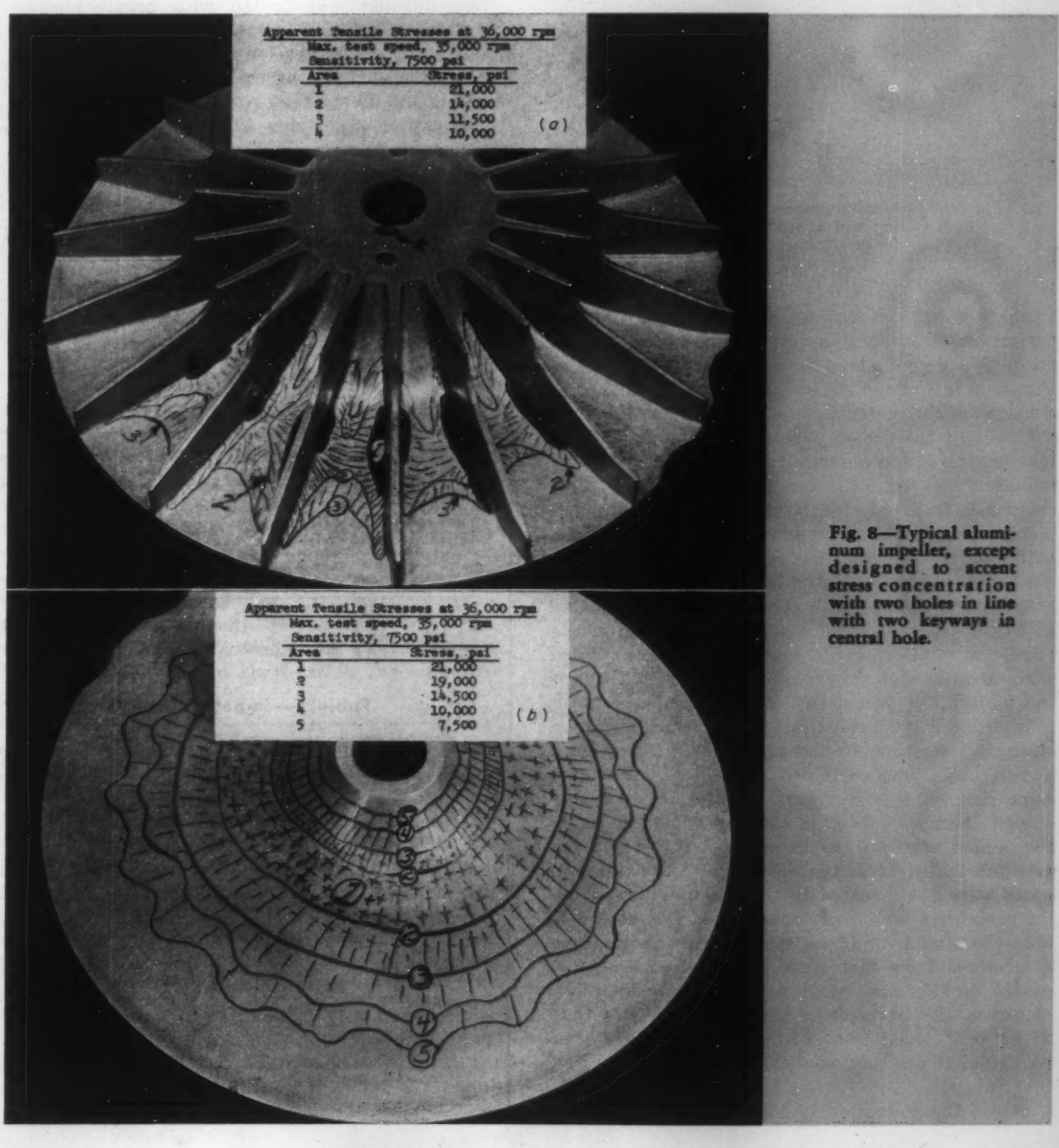


Fig. 8—Typical aluminum impeller, except designed to accent stress concentration with two holes in line with two keyways in central hole.

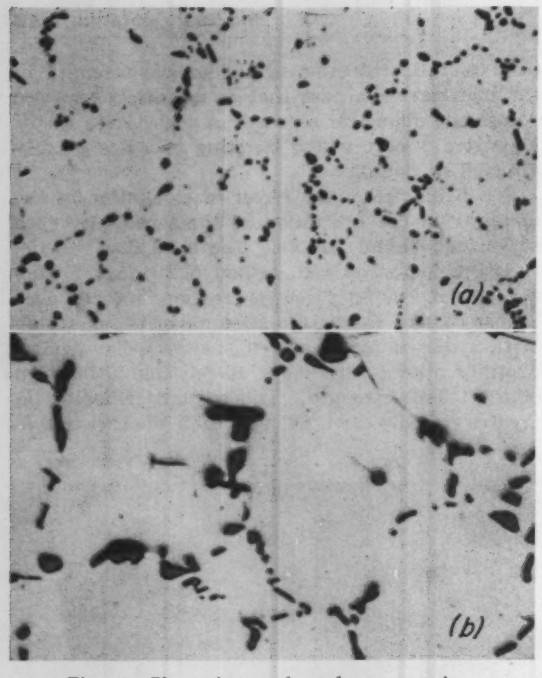


Fig. 9—Photomicrographs of, *a*, premium-strength casting and *b*, sand casting, both alloy C355-T61. (Magnification 250X, 0.5HF etch)

strength is utilized with an elongation of about 2½ per cent. With a low design factor such as <0.15, about 9 per cent elongation would be required to obtain a utilization of 80 per cent of the tensile strength of the material.

Effect of the design factor on utilization of the tensile strength is shown in Fig. 7, where two aluminum alloys in wide use for rotating parts are compared. One material, 2014-T6, is a wrought material having about 10 per cent elongation in the actual part. The other material, cast alloy 355-T62, has approximately 1 per cent elongation in the actual part. This graph confirms the information in Fig. 6. It points out that the utilization of the tensile properties of the material can be obtained with ideal design, regardless of the ductility of the material or the method of fabrication.

In Table 3 is shown the effect of ductility upon strength reduction for the same alloy. The results shown have been obtained with parts from the same cast ingot. Test parts in one set were machined from part of this cast ingot and parts in the second set were machined from forgings properly fabricated from the cast ingot. Both sets of parts were heat treated to the maximum mechanical properties of the material. It is interesting to note the similarity in ultimate tensile strength as determined from test bars cut from both sets of parts. In this case, yield strengths were identical. However, the parts from the ingot had less than 2 per cent elongation, while the properly forged parts had 10 per cent elongation.

Stress Concentration: Additional information on the effect of stress concentration factors upon strength reduction is shown in Table 4, where test results of bursting speed for a cast and forged aluminum alloy, having stress concentrators of different geometry, are listed. It can be seen how an increase in the design factor results from substituting splines for widely spaced keyways.

Confirmation of the data presented has been obtained from another type of test. An impeller of 9.4 in. diameter was designed within the limiting dimensions of a commercial application, Fig. 8. Fig. 8*a*, the front side, shows the central bore having two keyways 180 deg apart, together with two drilled holes in line with the keyways. This arrangement creates the stress concentration on one plane. Of course, from a stress standpoint, location of the holes 90 deg from the keyways would be preferred.

This impeller was coated with brittle lacquer (Stresscoat) and then rotated at increasing increments of speed to develop the elastic stress pattern on the surfaces of the impeller. The values shown in the illustrations are the apparent stresses for a speed of 36,000 rpm. This test was conducted under controlled temperature conditions with a Stresscoat sensitivity of 7500 psi apparent stress.

Although this impeller had a central hole with two keyways 180 deg apart and two drilled holes in line with the keyways, the highest stress was indicated at the root of the blade about midway in the length of the blade. The Stresscoat pattern developed on the rear of the impeller gives approxi-

Table 4—Effect of Keyways and Splines

	Cast Aluminum 355-T6	Forged Aluminum 2014-T6
Burst speed, smooth bore (rpm)	23,500	40,000
Burst speed with keyway (rpm)	17,000	34,000
Strength reduction factor	1.94	1.38
Burst speed with splines (rpm)	20,350	37,250
Strength reduction factor	1.34	1.15

Disc: 12 in. OD by 2½ in. ID.
Keyways: Two, 180-deg apart, ⅜ in. wide by 3/16 in. deep, with 1/64 in. radius.
Spline: 16/32 DP involute, with 0.014 in. radius at addendum.

Table 5—Impeller Test Data

Location	Orientation	Tensile Strength (psi)	Yield Strength (psi)	Elongation (per cent)
Hub*	Axial	46,700	35,100	8.0
Midway*	Radial	46,700	35,800	8.0
Periphery*	Tangential	46,700	35,000	5.3
Minimum, irrespective of location		45,600	34,600	5.0

Average Stress: 45,000 psi for a burst speed of 61,200 rpm (2510 fps)

Alloy	Number of Impellers	Burst Speed (rpm) Max	Min
355-T61	2	53,250	51,500
A355-T61	2	52,000	48,750
C355-T61	4	61,300	60,400
C355-T62	2	61,300	58,000
A356-T62	2	59,800	59,750
XA140-T2	2	45,400	44,850
142-T77	2	46,700	46,000

*Average of two tests at each location.

mately the same magnitude of apparent stresses as the bladed side of the impeller. However, the stress pattern on the back of the impeller indicates at the location of the peak stress a condition of stress approaching a uniform biaxial stress.

All the stresses indicated in Fig. 8 are well within the elastic limit of the material for a speed of 36,000 rpm. It would be expected that these stresses would increase proportionally to the speed squared as long as the stresses are within the elastic limit of the material. Thus, with a very brittle material, it would be expected that rupture would take place when a stress in the impeller reached the tensile strength of the material. This result would not hold for impellers fabricated from a material capable of yielding. The instant that any yielding of the material takes place, a redistribution of stress takes place, creating a new stress system.

In this test, all impellers were produced by means of the premium-strength casting process. Thus, advantage was taken of the high uniformity of properties in any one part, as well as of the duplication of properties between castings. These impellers were of alloys 355-T61, A355-T61, C355-T61, A356-T62, XA140-T2, C355-T62 and 142-T77.

The cast structure of the premium-strength process is shown in Fig. 9*a*, in comparison with the structure of a conventional sand casting, Fig. 9*b*. The properties of test bars machined from a C355-T61 alloy premium-strength impeller of the test lot are given in Table 5.

Temperature: A minimum of six test bars was machined from an impeller of each alloy used in the foregoing test. From this information, the graph shown in Fig. 10 was obtained. Fig. 10 shows the percentage of tensile strength utilized by each impeller at bursting speed. Upon this graph, the results obtained for alloys having properties suitable for operation above 400 F are enclosed in a circle. While an impeller does not operate at a uniform temperature, being cooler at the inducer end, it may be subjected to an elevated temperature for considerable periods of time after operation due to the heat in the surrounding structure.

Wrought aluminum alloys 2014-T6 and 2025-T6 and casting alloys 355-T61, C355-T61, C355-T62, 356-T62 and A356-T62 are recommended for rotating parts having a maximum operating temperature of 350 F. Wrought alloy 2618-T61 may allow some increase in operating temperature above 350 F. Casting alloy XA140-T2 is outstanding in elevated temperature properties as it maintains approximately the same mechanical properties (tensile strength, yield strength and elongation) at any temperature up to 400 F for 10,000 hr.

Vibration: Fig. 11 shows four design possibilities. In Design A, the inducer section has been designed as a separate part and is coupled to the impeller section by means of driving pins. All four possibilities are designed to be driven by splines. In some applications, the splines are located at the front end of the impeller section. Design A can be fabricated from either cast or wrought material. Design B, in which the inducer section and impeller section have been combined, can be fabricated by

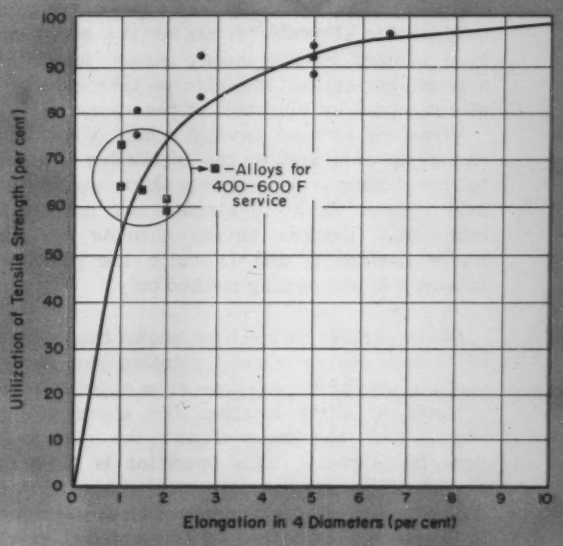


Fig. 10—Percentage of tensile strength utilized (average stress at rupture ÷ tensile strength) for various aluminum alloys. Samples were machined from 9.4-in. diam impeller shown in Fig. 8 fabricated by premium-strength process. Test bars showed 34,000 to 51,900 psi tensile strength and 1.3 to 14 per cent elongation.

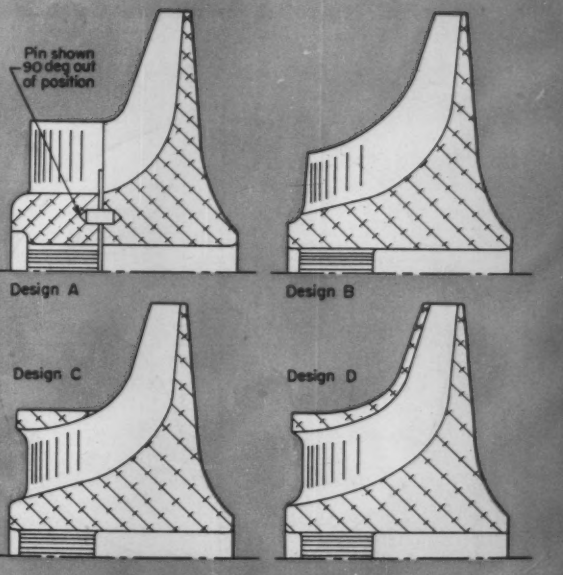


Fig. 11 — Various impeller designs. Shrouded Designs C and D minimize vibration in contrast to Designs A and B.

the same procedures as Design A.

Both Designs A and B are handicapped by vibration of the vanes. Any vibration of these vanes creates a repeated stress, generally at a relatively high frequency. This stress is superimposed on the inertia stresses, which are steady stresses resulting from the rotation of the part. If the part is operating at a relatively high speed, the greater part of the allowable stress of the material has been utilized by the steady stress, leaving only a small percentage available to take care of any stress set up by vibration of the vanes.

Vibratory stresses usually occur at the inducer end of the vane and, by the application of a shroud to this section or by complete shrouding of the impeller, these vibratory stresses are reduced to a minimum. Designs having shrouds are shown under Designs C and D which are practical to fabricate by the casting method only.

Overspeeding: It has been known that some kind of change occurs when a rotating part is driven for a short period of time at a speed where the stresses at some location are above the yield strength of the material and the part is then brought to rest. This operation is often called overspeeding.

The beneficial effect obtained from overspeeding is due to a plastic flow of the material, resulting in a favorable distribution of residual stresses. As an example, a uniformly thick disc with a central hole may be used. In such a disc, the maximum elastic stress is set up at the central hole. This is a tangential or hoop stress. When this disc is rotated, a speed is reached at which the sum of the initial tangential stress, plus the tangential stress due to rotation, equals the proportional limit of the disc material. Such a stress distribution is shown by Curve D in Fig. 12. With increasing speed, the stress distribution will attempt to reach a value as shown by Curve A but which could not exist and be compatible with the ultimate strength of the material. Any yielding of the material would result in a redistribution similar to dotted Curve B.

When such a part is brought to rest, a residual stress distribution would be set up, Curve E. The material that had been plastically deformed is now compressed by the material that was stressed elastically, resulting in a state of equilibrium represented by Curve E. When the disc is brought up to the former speed, the new distribution would be the algebraic addition of Curve E and Curve A.

Experience indicates that it is advisable to overspeed a part at a speed equal to 120 per cent of the maximum operating speed expected in service. The bursting speed of the part should be 140 per cent of the maximum speed in service. Proof speeding at a speed well above the speed expected in service not only provides a tool for inspection and quality control but also provides resistance to rupture and time-dependent deformations.

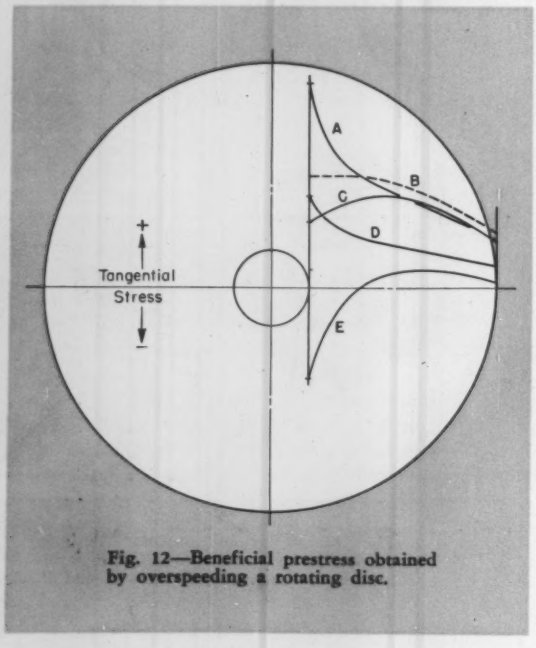


Fig. 12—Beneficial prestress obtained by overspeeding a rotating disc.

Conclusion: Evidence has been presented showing the effects of design upon the bursting strength of high-speed rotating parts. The best of designs requires only a small amount of ductility to utilize the tensile strength of the material. As a design departs from the ideal geometry, ductility of the material is required to minimize the strength reduction that accompanies stress concentrations.

ACKNOWLEDGMENT: The author wishes to express his appreciation to George A. Butz, senior test engineer of Alcoa's Cleveland Development Division Laboratory, for his help in the testing program, and to George R. Gardner, assistant chief of the Cleveland branch of the Alcoa Research Laboratory, who was responsible for the development of the premium-strength impeller castings.

Tips and Techniques

Finding the Design Manual

Many drafting rooms are such vast areas that it is often difficult to locate the reference volumes which are used by all the designers. These design manuals are usually cumbersome and because of size, there is usually only a single copy in the area. To assist users in locating this volume, which is on a portable stand, the engineering department of a west-coast aircraft plant does this: The stand on which the book rests has been fitted with a small red pennant atop a staff. The pennant is easily seen over the heads of the artists and designers. The man needing the volume has only to take a quick look around the room to see the pennant and locate the book.—GLEN F. STILLWELL, *Manhattan Beach, Calif.*

GRAPHICAL INTEGRATION

Specially designed charts form the basis for a method of graphical integration which is reasonably fast, accurate and simple.

By J. WOLAK
Mechanical Engineering Dept.
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OFTEN, it is necessary to determine the value of an integral in which one function can be readily defined mathematically, and the other defined either graphically or in mathematical terms which are difficult, if not impossible, to interpret analytically. Such functions take the general form of

$$\int f(x)\,g(x)\,dx$$

where $f(x)$ is some known, continuous, single-valued and integrable function of x within the required limits of integration. Again, function $g(x)$ may be given graphically but need not be expressible in simple mathematical terms and may be subject to sudden variation.

Typical examples of such functions are listed below. Where $f(x)$ is the same for several integrals which have to be determined, the method described here

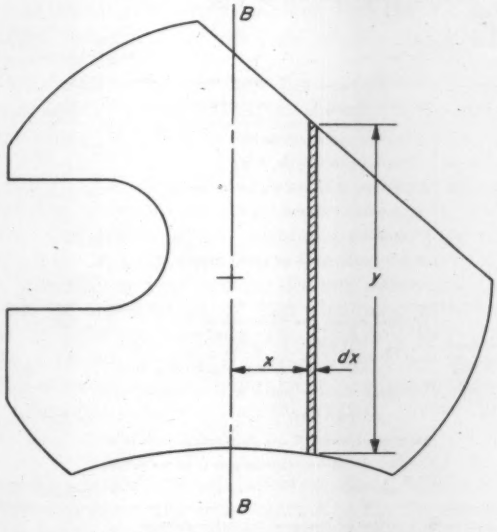

Fig. 1—Section for which it is required to find distance, $\bar{x}$, of center of gravity from arbitrarily chosen axis BB, and second moment of area, I_{BB}.

The method of graphical integration is particularly applicable to functions which fit the general form of

$$\int f(x)\,g(x)\,dx$$

The following are examples of such functions:

1. First Moment of Area

$$\int xy\,dx$$

Here, x corresponds to $f(x)$, and y corresponds to $g(x)$.

2. Second Moment of Area

$$\int x^2 y\,dx$$

Here, x^2 corresponds to $f(x)$, and y corresponds to $g(x)$.

3. When discharge is subject to pure viscous flow, time t required for fluid level h to fall from h_1 to h_2 in a tank of given cross-sectional area A which varies with h, is given by

$$t = c\int_{h_1}^{h_2} \frac{A}{h}\,dh$$

Here, $1/h$ corresponds to $f(x)$, A corresponds to $g(x)$, and c is constant.

4. Similar to 3, but viscous effects negligible, time t is given by

$$t = k\int_{h_1}^{h_2} \frac{A}{\sqrt{h}}\,dh$$

Here, $1/\sqrt{h}$ corresponds to $f(x)$, A corresponds to $g(x)$, and k is constant.

here is particularly useful and depends on special charts and a planimeter.

Though this discussion concerns properties of areas, principles may be adapted to other problems expressible by an integral of the general form providing that, within the limits of integration,

$$Z = \int f(x)\,dx$$

is not multivalued or imaginary, is continuous, and its slope, $f(x)$, is graphically determinable.

First Moment of Area: As an example, suppose it is required to find the distance of the center of gravity of a section, Fig. 1, from an arbitrarily chosen line, *BB*. Using the notation of Fig. 1,

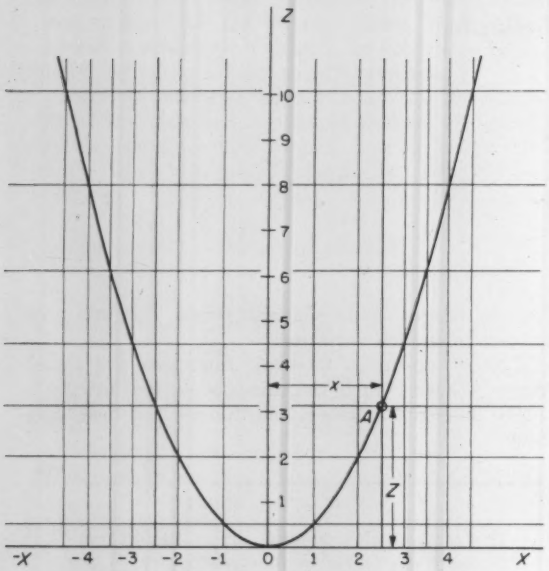

Fig. 2—Chart for curve of $Z = x^2/2$, which can be used for determination of first moment of area.

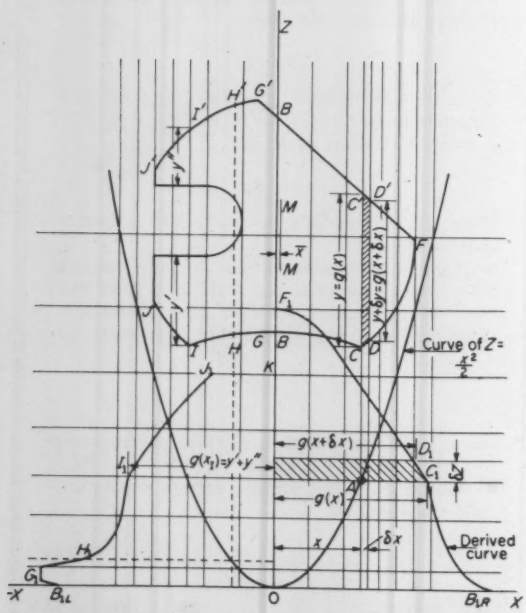

Fig. 3—Section of Fig. 1 superimposed on Fig. 2. First moment of area about axis *0Z* of the part of section to the right of *0Z* is represented by area defined by derived section $0B_{1R}C_1D_1F_10$.

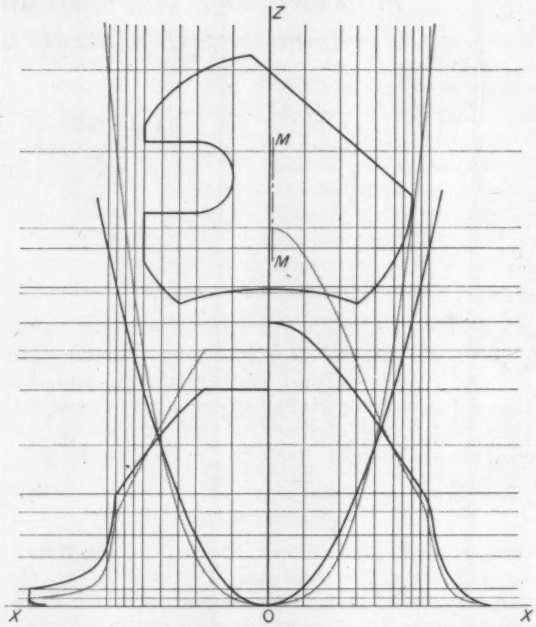

Fig. 4—Solution of problem. Black and gray lines refer to first and second moments of area respectively. Numerical results of integration are tabulated in the sample form shown in Fig. 5 below.

	1. Part No. _____ 2. Dwg. No. Fig 1 3. Scale* Full Size	
	4. Section+ _____ 5. Area of section as drawn = 33.6 cm²	
	6. Chart No. 6 7. Chart constants C=1, K=2 Units: cm	
1st Moment of Area	8. Derived area to left of OZ	24.8
	9. Derived area to right of OZ	28.1
	10. Positive difference between (8) and (9)	3.3
	11. Distance $\bar{x}$ to center of gravity from OZ (drawing), (10) x c/(5)	=0.1 cm
	12. Distance to center of gravity from OZ (actual) (11)/(3)	$= \frac{0.1}{1}$ =0.1 cm
2nd Moment of Area	13. Total derived area (both sides of OZ)	58.5
	14. I_{BB} = (13) x k	=58.5x2=117.0 cm⁴
	15. 2nd moment of area about axis parallel to OZ but through center of gravity of the section (as drawn) = I_{BB} - (11)² x (5)	=116.7cm⁴
	16. True 2nd moment of area about axis parallel to OZ (RB) but through center of gravity of the section: I_{RB} = (15)/(3)⁴	$= \frac{116.7}{1}$ =116.7 cm⁴

*Scale to which section has been drawn for this calculation

+Position of section of the part considered, as designated on drawing

Fig. 5—Suggested form for tabulating results of graphical integration. Figures shown are those of sample problem solution with Chart 5, Table 1, where $c = 1$ and $k = 2$.

$$\bar{x} = \frac{\int xydx}{\int ydx}$$

Note that in

$$\int xy\,dx$$

x corresponds to function $f(x)$, and y corresponds to function $g(x)$. Let

$$Z = \int xdx = \frac{x^2}{2}$$

The constant of integration is assumed to be zero since the rate of change of Z, and not its actual value, is required.

Fig. 2 shows a chart for the curve of $Z = x^2/2$. Two co-ordinates are drawn through each plotted point. Units for charts could be different from those used in dimensioning the section, but a correction factor must be applied if values sought are to be in the same units as those of the section.

Draw the section of Fig. 1 on tracing paper and place it over the chart of Fig. 2 so that line BB coincides with axis $0Z$ as shown in Fig. 3. Vertical displacement of the section relative to the XX axis of the chart is immaterial. Draw, on the tracing paper, lines to coincide with axes XX and $0Z$. These form a permanent reference between tracing paper and chart. All remaining operations are performed on the tracing paper.

Referring to Fig. 3, the ordinate at X cuts the section contours at points C and C', and the curve of $Z = x^2/2$ at point A. With a compass, measure CC' and, starting from axis $0Z$ (BB), mark length CC' on the abscissa drawn through point A to obtain point C_1. Repeat the procedure for other ordinates.

Note that $0Z$ is also an ordinate. The corresponding value of $g(0)$ must be plotted on the XX axis giving points B_{1R} to the right of $0Z$, and B_{1L} to the left of $0Z$.

Where any ordinate cuts the section more than once, as at II' to the left of $0Z$, the sum of the intercepts must be used for $g(x_I)$, i.e., $g(x_I) = y' + y''$.

Where contours of the section change rather abruptly between any two ordinates, as at HH', additional points for the derived curve may be obtained by drawing an ordinate (dashed line, Fig. 3) to cut the section where desired. Through the point of intersection of this ordinate with the curve, draw an abscissa line. Measure and plot $g(x_H)$ to obtain point H_1. Repeat for other values of x if necessary. Although it is the chart which is primarily designed for integration, curve

$$Z = \int f(x)dx$$

may be used for interpolation as at HH', Fig. 3.

Draw a curve through points B_{1R}, C_1, D_1, etc. on each side of $0Z$. Portions of the derived curve which correspond to smooth contours of the section must be equally smooth. Any sudden variation indicates an error in plotting the derived curve.

The area bounded by $0B_{1R}C_1D_1F_10$ represents the first moment of area about $0Z$ of the part of the section to the right of $0Z$ (BB). Similarly, for the opposite side, the first moment of area about $0Z$ (BB) is represented by the area bounded by $0B_{1L}G_1H_1I_1J_1K0$.

With a planimeter, measure the area of the section and the two derived areas. The positive difference between the two derived areas, divided by the area of the section is equal to the value of $\bar{x}$. The center of gravity of the section is on that side of $0Z$ (BB), on which the derived area is greater. In Fig. 3, the derived area is greater on the right. Therefore, line MM drawn parallel to BB $\bar{x}$ units to the right of it, passes through the center of gravity of the section.

Justification of the Method: Referring again to Fig. 3, the first moment of area of the vertical strip $CDD'C'$ about $0Z$ is given by

$$\delta M \approx \left[\frac{g(x) + g(x+\delta x)}{2}\right]\left(x + \frac{\delta x}{2}\right)\delta x \qquad (1)$$

Area of the horizontal cross-hatched strip is given by

$$\delta A \approx \left[\frac{g(x) + g(x+\delta x)}{2}\right] \times \delta Z \qquad (2)$$

Since, in this case,

$$Z = \frac{x^2}{2}, \quad \frac{dZ}{dx} = x$$

Therefore, at

$$\left(x + \frac{\delta x}{2}\right), \quad \delta Z \approx \frac{dZ}{dx}\delta x = \left(x + \frac{\delta x}{2}\right)\delta x \qquad (3)$$

Substituting Equation 3 in 2

$$\delta A \approx \left[\frac{g(x) + g(x+\delta x)}{2}\right]\left(x + \frac{\delta x}{2}\right)\delta x \qquad (4)$$

Thus, δA represents, to a scale, δM. The area between the derived curve $B_{1R}C_1D_1F_1$ and axes $0Z$ and $0X$ represents the first moment of area about

Fig. 6—Type of section which requires different charts for determining moments of area about axes BB and TT.

0Z of the part of the section to the right of 0Z. Similar reasoning applies to the left side.

Second Moment of Area: Second moment of area is given by

$$I = \int x^2 y dx$$

Here, x^2 corresponds to $f(x)$, and y corresponds to $g(x)$. Let

$$Z = \int f(x)\,dx = \int x^2\,dx = \frac{x^3}{3}$$

the constant of integration being assumed zero.

Since the rate of change of Z with respect to x, and the derived areas (irrespective of sign) are of interest, both arms of curve $Z = x^3/3$ will be drawn upwards. This arrangement facilitates preparation of a chart, and the curve of $Z = x^3/3$ may be drawn. The integral

$$\int x^2 y\,dx$$

can be evaluated in exactly the same way as that for the first moment. In this case, the sum of the derived areas on the two sides of 0Z (BB) represents the second moment of area, I_{BB}.

Since the value of $\overline{x}$ is known, the second moment of area about MM, parallel to BB but through the center of gravity, is given by

$$I_{MM} = I_{BB} - (\overline{x})^2 \times \text{area of section}$$

Chart Combination, Area Size: Development of derived curves for both first and second moments of area was considered separately. Since the value of y for any corresponding value of x is the same for both moments, the same compass setting may be used for marking both moments simultaneously. This may be done by drawing the two charts on a single sheet of paper. Charts should have common ordinates, although the abscissas will, in general, be different.

Charts of various sizes may be constructed by employing suitable values for coefficients c and k in $Z = x^2/2c$ and $Z = x^3/3k$.

Table 1 lists suggested chart combinations which are suitable for almost any section whose width falls within the range of 1 to 28 units.

Table 1—Chart Combinations

Chart No.	Values of x	—Equations— 1st Moment $Z = x^2/2c$	2nd Moment $Z = x^3/3k$	Multiply Derived Areas by c For 1st Moment	k For 2nd Moment
1	0 to 0.9	$5x^2$	$5x^3$	1/10	1/15
2	0 to 1.4	$3x^2$	$2x^3$	1/6	1/6
3	0 to 2.0	$2x^2$	x^3	1/4	1/3
4	0 to 3.4	x^2	$x^3/3$	1/2	1
5	0 to 5.0	$x^2/2$	$x^3/6$	1	2
6	0 to 7.0	$x^2/2$	$x^3/12$	1	4
7	0 to 10.5	$x^2/4$	$x^3/30$	2	10
8	0 to 14.0	$x^2/6$	$x^3/60$	3	20

Derived curves for first and second moments of the section of Fig. 1 about BB (0Z) are shown in Fig. 4. Chart 5 of Table 1 was used to evaluate moments. Gray lines of Fig. 4 refer to second moment of area, I_{BB}.

Practical Applications: For a given section drawn on tracing paper, select a chart of suitable size and place under the paper. Draw reference axes XX and 0Z, and derive the required curves as described. With a planimeter, determine the areas between the curves and axes, as well as the area of the section. Enter these values on a form of the type shown in Fig. 5, which contains values of Fig. 4.

Multiply derived areas by appropriate chart coefficients to obtain properties of the section as drawn. Multiply by the scale factor resulting from the scale to which the section was drawn, to obtain actual values.

For a section of the type shown in Fig. 6, it may be necessary to use one chart for determining properties sought about an axis such as BB, and another chart for determining properties about axis TT.

ACKNOWLEDGEMENT

The author wishes to thank Mr. Norman Elce, Director and Chief Mechanical Engineer, Metropolitan-Vickers Electrical Co. Ltd., London, England, for permission to publish this article.

They Say . . .

"The target for any development, design and manufacture of an equipment or system is to reliably satisfy its functional and operational requirements. Reliability may be considered in terms of a goal established by theoretical considerations based on past experiences, or in the case of commercial equipment, in terms of the reliability compared to competitive products."—L. R. ZIMOV and P. F. G. HOLST, *Crosley Div., Avco Mfg. Corp., Cincinnati, Ohio.*

"To put it bluntly, no reliability program will ever succeed unless motivated and guided by a dynamic will which knows and acts on the knowledge that reliability can and must be achieved. A reliability program is frontier work and it takes all the knowledge, stamina and courage that can be mustered in the face of unending discouragement and crosspurposes to see such a program through to a successful conclusion."—COMMANDER CHARLES R. BANKS, USN.

Conductive and Resistive Coatings

By R. J. PHAIR
Chemical Research
Bell Telephone Laboratories Inc.
New York, N. Y.

Frequently, components require a thin conducting layer of specified size, shape and resistance to serve as an electrical shield or to perform an actual circuit function. Resins or lacquers, pigmented with metals or carbon, can be applied like paint to give thin resistive films in complex patterns.

ONE of the less well-known uses for paint or organic coatings is to conduct electricity. Proper dispersion of certain types of metallic or carbon pigments in resinous binder results in a coating that is electrically conductive.

Such coatings can be very useful and have served as electrical shields on electron tubes, for example, and on radar housings and plastic-encapsulated components. Other applications include resistor terminations, printed-wiring circuits, flexible waveguides, loss-producing elements in microwave attenuators, and many other areas where thin conductive films are required.

The vehicle used to contain the conductive pigment may be any one of a great variety of air-drying or oven-drying substances. Electrical conductivity is developed in the coating by particle-to-particle contact. Particles are dispersed uniformly throughout the coating which results in a multiplicity of paths in all directions. Film electrical conductivity depends upon concentration and conductivity of particles, and resistances of the particle-to-particle contacts. Overall resistance of a conductive coating is described as a certain number of ohms per square. Factors determining conductivity have nothing to do with size of area covered. In its circuit, the coating exhibits a resistance determined by its shape, that is, by the proportionate dimensions of the rectangular, square, or irregular area that it covers. For a square area of constant film thickness, resistance from one side to the opposite is constant regardless of size of the square.

For maximum conductivity, it is best to choose a metallic pigment that does not oxidize or combine chemically with the vehicle or atmosphere, or a pigment whose reaction products are also conductive. Such metallic pigments as aluminum and copper are eliminated, since these form nonconductive surface layers. Of the suitable pigments, finely divided silver is most frequently used, though special cases require gold or nickel. The silver most frequently employed is in the form of high-purity, flake-like particles averaging about 0.1 micron thick, 10 to 20 microns wide, and up to 40 microns long. With silver-pigmented coatings, resistance levels as low as 0.1 ohm per square are attainable.

For higher levels of resistance, 40 to 1000 ohms per square, graphite is used in flake form with an average size of 2.5 microns. Films of still higher resistance levels, 1000 ohms to the megohm region, are obtained by carbon black and graphite. Carbon black materials include acetylene and channel blacks. These materials are finer in particle size, and conductivity varies according to amount of graphite form of carbon present in the carbon black.

Characteristics of a typical conductive coating are shown in Fig. 1 and 2. Film is an acrylic ester polymer pigmented with silver. This coating air-dries and is suitable for use on many thermoplastic compounds. Electrical behavior of such a film, however, is largely independent of the vehicle, so Fig. 1 and 2 are typical of silver in a number of resinous binders.

The various concentrations refer to films of equal thickness (0.0003 in.). There is a rapid lowering of resistance with increasing silver content up to a concentration of 30 to 35 per cent. Higher pigmentation results in a small ad-

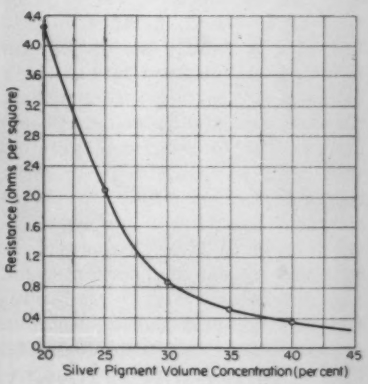

Fig. 1—Resistance of silver-pigmented film vs concentration of silver. Film thickness is constant at 0.0003 in.

ditional lowering of resistance, but considerations of expense and preservation of satisfactory film characteristics usually limit the concentration to a maximum of about 40 per cent.

Resistance can also be changed by changing thickness of the film as shown in Fig. 2. This curve

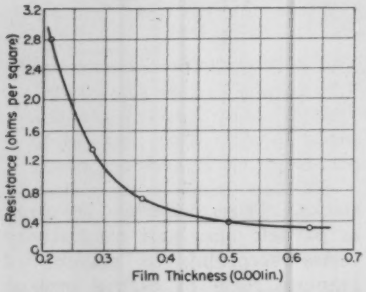

Fig. 2—Resistance vs thickness of film for 30 per cent by volume of silver

approximates the hyperbolic function $R = r(1/a)$, where r is a constant, and R, 1, and a are resistance, length, and cross-sectional area respectively of a conductor. For resistive films, this expression reduces to $R = r/t$, where R is resistance per square and t is thickness.

Silver-pigmented coatings approach maximum conductivity at thicknesses of 0.0006 to 0.0007 in. Thus, to achieve minimum resistance, films can be used at maximum silver concentration of 40 per cent to obtain a resistance as low as 0.06 ohm per square. This is about 50 to 60 times the resistance of silver or copper metal of identical dimensions. Further, copper foil used in printed-wiring circuits is usually about five times as thick as coated films. By comparison, resistance of silver-pigmented coatings is 250 to 300 times greater.

A film of graphite dispersion has a higher specific level of resistance than silver. As with silver-pigmented films, resistance is adjusted by varying concentration and thickness. Fig. 3 shows resistance-thickness curves for two concentrations of graphite. The curves illustrate another important consideration in designing for conductive films. By varying graphite content, the curve can be made to level out at any particular value of resistance. This allows more variation in film thickness without a marked change in resistance. When film thickness approaches 0.001 in., a 10 per cent variation in thickness has little effect on resistance value.

Careful control in applying films is necessary. An automatic spray machine has been developed for the purpose, and it is necessary to regulate precisely air-drying speed to build up required thicknesses in several layers. With this type of control, over-all resistance of a film can be held within ± 5 per cent of the nominal value, and variation of resistance over fairly large areas (12 by 12¼ in.) can be held within similar limits.

Unless there is absolute necessity for such close tolerances, 10 per cent variation in over-all resistance is allowed, although variation over adjacent sections of the area is maintained at ± 5 per cent. These remarks apply not only to graphite-pigmented coatings, but also to carbon-black coatings at higher levels of conductive-film resistance.

Typical characteristics of a carbon-pigmented coating are shown in Fig. 4. A 5 per cent change in pigment volume concentration changes resistance level by one order, and at 15 per cent extends the level to 100 megohms. Thus, a complete range of resistances from 0.10 to 10^8 ohms per square is obtained by proper selection of pigmentation and film thickness.

In all of these coatings, the organic binder holding the pigment is affected by environment. As temperature or humidity increases, the binder swells and the result is a less intimate particle-to-particle contact and, consequently, increased resistance. These effects have been measured for graphite-pigmented, air-dried films. For example, films of 8000 ohms per square increased in resistance by about 0.33 per cent for each per cent increase in relative humidity. Films of 200 ohms per square showed an increase of about 0.25 per cent. Vehicles cured by oven-baking can be used to reduce such temperature and humidity sensitivity. Silver-pigmented coatings

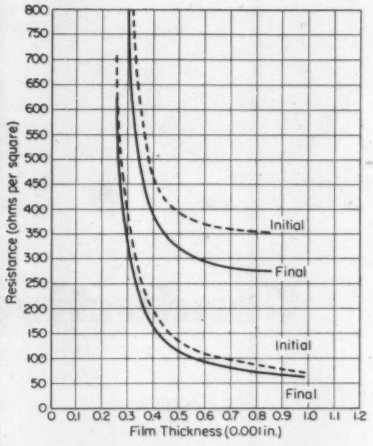

Fig. 3—Resistance vs thickness of film for two concentrations of graphite. Upper set of curves represents 28 per cent graphite by volume compared to 38 per cent for lower set. Dashed and solid lines illustrate effect of short-term aging.

show temperature and humidity coefficients of about one-third these values.

Air-dried films exhibit a short-term aging effect which apparently levels off after 8 to 10 days at a value about 25 per cent less than the original. The materials are not stable, however, and if the film is aged at 125 F, resistance continues to decrease gradually over a period of two years. Final value is less than 50 per cent of the original. While this is undesirable, it is difficult to avoid, especially when the film is applied to a temperature-sensitive base material such as or-

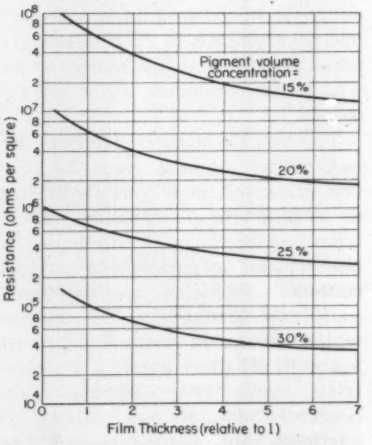

Fig. 4—Resistance vs film thickness for four concentrations of carbon black in acrylic ester polymer used as a binder

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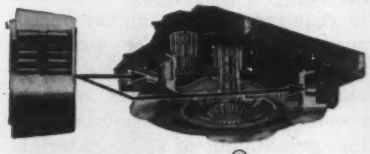

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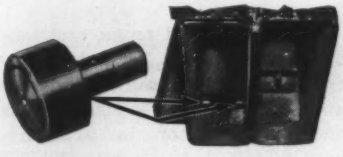

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ienting polystyrene. This material cannot be heated above 150 F without distorting the film.

Greater stability is attained with binders that are heat-cured at high baking temperatures. One example of this type of film is a resistive coating for which the binder is a silicone resin, and uses 40.5 per cent by volume of graphite as pigment. This film was developed to provide an electrical loss-producing element for microwave radio-relay systems.

Effects of prolonged baking and other processing required to achieve stability are shown in Fig. 5. The curve shows resistance history during baking of the graphite film over a period of 160 hr. The peak in the curve at 97 hr results from application of a clear over-coating at this time. The clear coating is applied for mechanical protection and as a moisture barrier against short-term increases in relative humidity. Temperature and humidity effects on this film are much reduced. Resistance increases about 0.12 per cent for a 1 degree F rise in temperature, and only about 0.05 per cent for a 1 per cent rise in relative humidity. Long-term stability is also considered to be improved. A film of 105 ohms per square aged for 5 months with periodic increases in temperature up to 300 F drops only 1 ohm to 104 per square.

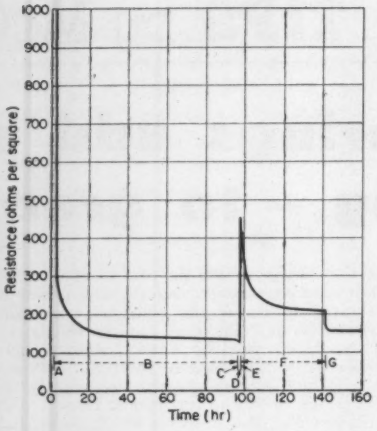


Fig. 5—Change in resistance of graphite-pigmented silicone coating during oven baking and application of clear cover-coating: *A*—coating air-dried 80 min, baked 30 min at 350 F. *B*—coating baked 94 hr 50 min at 480 F. *C*—removed from oven, cooled to room temperature for 50 min. *D*—clear cover coating applied. *E*—returned to oven at 482 F. *F*—baked 42 hr 20 min at 482 F. *G*—removed from oven and again cooled to room temperature

Films are not substitutes for metals where very low resistance is required, but at higher resistance values they offer many advantages. Where tailoring resistance to specific values may be a complex problem in mixing, fusing, or alloying of solid materials, metallic pigmenting of a liquid binder is often a much simpler procedure for certain applications. Temperature, humidity, and aging effects complicate design of films in some circumstances, but films are nevertheless preferable in many instances because they can be applied over irregular shapes and can also be applied in complex geometric patterns.

From "Conductive and Resistive Coatings," in Bell Laboratories Record, *September,* 1957.

Effect of Fastener Size on Joint Efficiency

By E. O. DICKERSON
North American Aviation Inc.
Los Angeles, Calif.

As sheet materials for joints become thicker and stronger, fasteners must get larger to maintain high joint efficiency

INFLUENCE of fastener size and fastener-to-sheet strength ratio on mechanical joint efficiency is shown in Fig. 1 and 2 for simple, single-shear joints. These curves are based on a ratio of 1 for fastener shear to sheet tensile capability. Higher ratios yield higher efficiencies only if sheet bearing capability is not limiting.

To maintain high joint efficiency, fastener diameter should increase in direct proportion to sheet gage when fastener shear is critical. Meeting arbitrary requirements of fastener specifications does not assure fastener fatigue capability for every possible application, but merely sets a level of performance for designers.

Methods for calculating creep in shear-type joints require data on creep rate of fastener material in shear, and creep rate of sheet material in tension, shear, and bearing. It is also necessary to determine loading and temperature to which joints will be subjected, relationship of these factors, and how much total deformation can be tolerated.

Creep in threaded fasteners is the relaxation or loss of initial torque or preload. It is due to high bearing and shearing stresses in thread and head areas, and tension in the shank. This deformation with time lowers clamp-up forces and stress levels. Unless some other factor is present,

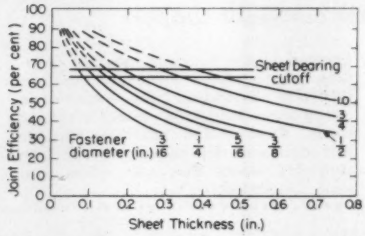
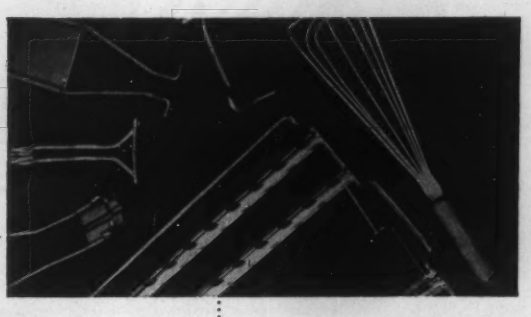


Fig. 1—Influence of fastener diameter on efficiency of single-row joints. Ratio of shear strength of the fastener to tensile strength of the sheet equals 1.



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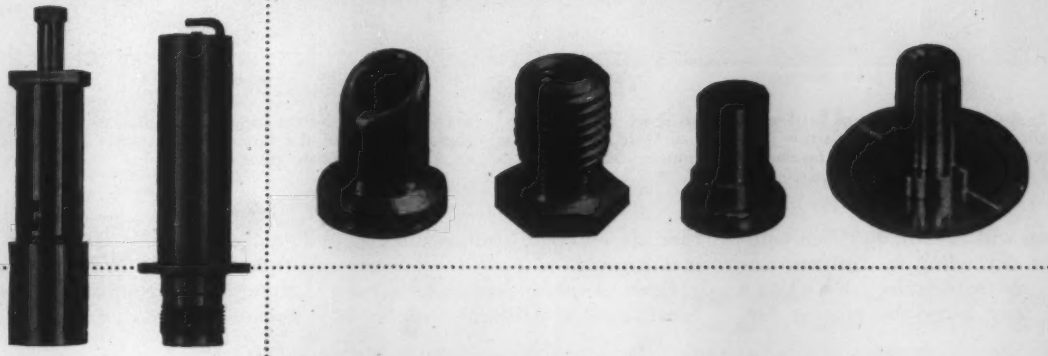

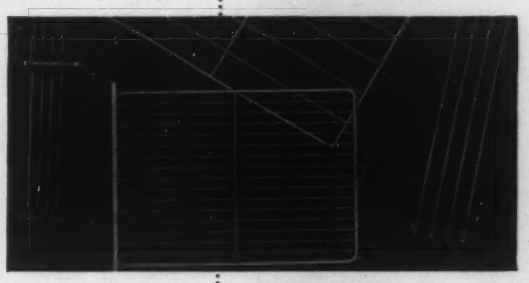

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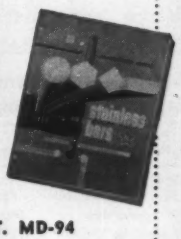

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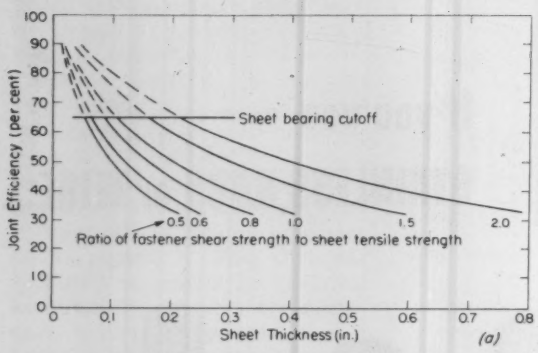
Joint Efficiency (per cent)
Sheet bearing cutoff
0.5 0.6 0.8 1.0 1.5 2.0
Ratio of fastener shear strength to sheet tensile strength
Sheet Thickness (in.)
(a)

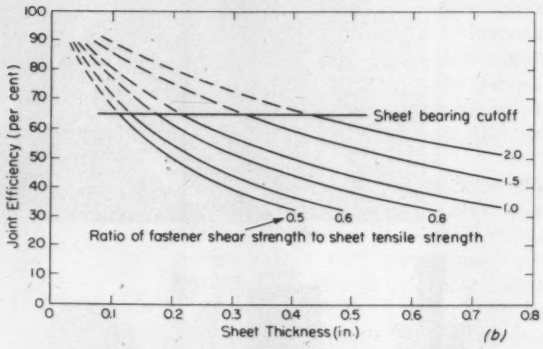

Fig. 2—Influence of ratio of fastener shear to sheet tensile strength on efficiency of single-row joints for, *a*, ¼ in. diam fastener and, *b* ½ in. diam fastener. Optimum strengths are determined by equating tensile capacity of the sheet to shear strength of the fastener, using sheet bearing strength as a limiting cutoff value.

stresses will eventually reach equilibrium depending on fastener-material characteristics. Factors which may carry the process further are external loading and thermal stresses.

From a paper entitled "Structural and Mechanical Joints in Piloted Aircraft," presented at the High-Strength, High-Temperature Materials for Standard Parts Symposium in Dallas, June, 1957.

Thermal-Creep Design Criteria

By **ROBERT GOLDIN**
Bell Aircraft Corp.
Buffalo, N. Y.

Presented here are criteria needed by designers for analysis of structures involving high temperatures

FOR structures at room temperature, material properties used by stress analysts are basically those shown in Table 1. Each represents specific physical characteristics which determine adequacy of performance of structures from various strength standpoints. Yield strength is required because a visibly distorted structure may be unserviceable, and is almost invariably condemned as unsafe. Ultimate strength is checked so that at least some margin will exist beyond required performance prior to occurrence of catastrophic failure. Fatigue strength is needed so that life endurance is achieved. Rigidity is required so that mechanical interferences and adverse phenomena are avoided.

In any specific structural element, more than one of these four characteristics may closely govern design. Fundamental physical material properties related to these are indicated in Table 1 for structures at room temperature, and in Table 2 for structures at elevated temperatures.

Design engineers at times proceed with structural design without consciously realizing that these four strengths are to be considered. The most popular characteristic for governing strength computations is ultimate strength. Sometimes, yield allowables (yield strengths) of certain materials are about half the ultimate allowables (ultimate strengths) and, in such cases, yield strength governs design. Fatigue strength has become increasingly important but, as yet, remains a minor factor in determining cross-sectional areas and hence structural weight. Rigidity is becoming quite significant, and is definitely governing structural design and airframe weight. In

Table 1—Design-Material Properties for Structures at Room Temperature

Strength Characteristic	Physical Property	Parameter Measured
Yield	Yield allowable	Stress at 0.2 per cent strain set
Ultimate	Ultimate allowable	Stress at failure
Fatigue	S-N properties	Failing stress vs cycles
Rigidity	Modulus of elasticity	Stress vs strain

Table 2—Design-Material Properties for Structures at Elevated Temperatures

Strength Characteristic	Physical Property	Parameter Measured
Yield	Creep-set allowable	Stress at 0.2 per cent creep set
Ultimate	Stress-rupture allowable	Stress at creep-rupture
Fatigue	S-N properties	Failing stress vs cycles
Rigidity	Modulus of elasticity	Stress vs strain at temperature

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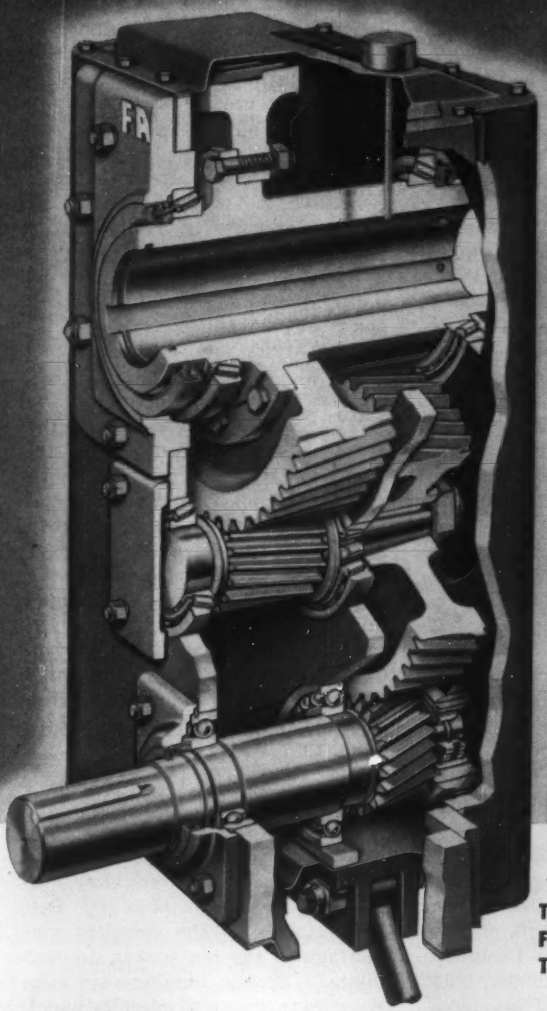

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this case, some governing tolerable deformation or rate of deformation becomes the criterion, and modulus of elasticity is the key material characteristic which governs structural size.

Creep and Allowable Yield Stress: In considering criteria associated with permanent deformation or yield, a number of factors are involved. Permanent deformation many times involves geometric distortion which renders the component at least partially inadequate in accomplishing its intended function. Secondly, permanent deformation is characteristically taken as a sign that loadings above those used in design have been experienced, and have thereby damaged the structure. Also, permanent deformation is taken as a sign of weakness in original design in that the structure may not be as capable of carrying design load as it was before such yielding occurred.

Since deformation due to creep has precisely the same external effects as those due to yield, it is logical to conclude that the arbitrary permissible creep-set should be taken as 0.2 per cent, identical to that established for strain. This is not a new proposal, but full appreciation of the practical reasonableness of this criterion has not yet occurred.

Based on discussions of yield and creep deformations, it is proposed that the same material-allowable permanent deformation criterion be applied for design, namely, 0.2 per cent permanent set. For design situations where permanent deformation is the governing factor, the criterion needed by the stress analyst is defined for the great majority of cases.

Creep and Allowable Ultimate Stress: A more controversial design area involves the problem of providing some ultimate strength level for heated structures. It has often been contended that the 1.5 factor of safety frequently used in cold-structure design cannot be used realistically in more complicated design areas. In checking cold-structure design, limit load is used to find stress, stress is multiplied by 1.5, and the result compared with the ultimate material-allowable to verify required cross-sectional area. If buckling is involved, it is required that 1.5 times the limit load be carried by the structure without experiencing catastrophic failure. If this concept is carried over to heated structures, it superimposes a drastic load conservatism for time-duration of design load and temperature of the structure at the time design-load occurs. To compensate for these and make it possible to perform design calculations in a practical manner, some new criterion is needed relative to ultimate strength.

Present creep stress-rupture curves are all plotted to provide the stress level which, if held for the entire time at load and temperature, will result in failure. Some designers use the creep stress-rupture curve and calculate a cross-sectional area which results in a stress two-thirds less than the rupture allowable.

Elevated-Temperature Fatigue: From a designer's standpoint, the most obscure of the four strengths to deal with analytically is fatigue strength. Fatigue refers to repeated application and removal of load. What is done in creep analysis with respect to ultimate strength criterion closely patterns what might be done in fatigue analysis.

From a paper entitled "Thermal Creep Design Criteria," presented at the National Summer Meeting of the IAS in Los Angeles, Calif., June, 1957.

Voice-Actuated Machines

Research on characteristics of acoustic properties of speech has opened the possibility of machines which understand and react to voiced commands

VOICE-ACTUATED machines seem logically feasible because devices which are counterparts of physiological processes already exist. Microphones "hear," computers "think," and motors "work." Measurable physical properties of spoken commands must be translated into phonetic information or meaning. Understanding must be based on certain meaningful characteristics of speech while other properties must be irrelevant.

A normal human emits hundreds of distinct unit sounds which listeners differentiate consistently. All words in the English language can be synthesized from only forty related groups of unit sounds, or phonemes. Designers of voice-actuated machines must derive phonemic data from physical measurements of speech and incorporate such provisions into memory circuits of the machine's computing brain. Considerable progress has been made in deriving phonemic data from measured speech.

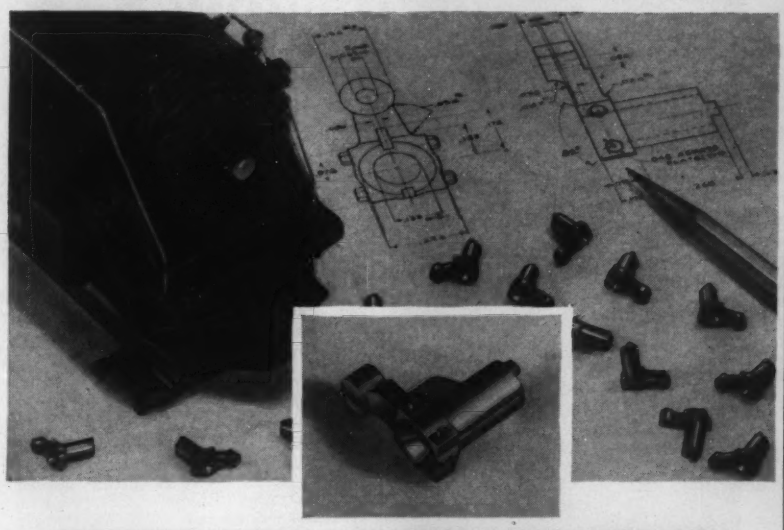
Properties of speech are revealed by studying its energy distribution as a function of time. Three-dimensional models of words have been made from sound spectrograms, and are known as "solid sound." These models relate frequency, time, and intensity, and are being used as aids in modifying techniques for actuating machines by voice.

A voice actuated machine, the Automatic Digit Recognizer, or AUDREY, has been built by Bell Laboratories. The circuitry can distinguish the ten spoken decimal digits. Spoken numbers are analyzed by a group of circuits which determines energy distribution. A computer then compares this information with stored patterns and decides which is the nearest match. The machine actuates a light to indicate which digit has been selected. Elapsed time for these three operations is about 200 milliseconds. If incoming sounds are poorly matched to stored energy patterns, AUDREY makes no choice at all. She does not respond well to female voices.

From "Voice-Actuated Machines: Problems and Possibilities," in Bell Laboratories Record, *Vol.* 35, *No.* 8, *August,* 1957, *by E. E. David Jr., Acoustics Research.*

GRC DIE CASTING HELPS LIONEL ACHIEVE TINY PART AUTHENTICITY

Tiny, intricate, too costly to make in their own plant, GRC's specialized techniques made this toy crank economically possible



While it would seem more advantageous for manufacturers to make all parts in their own plants, some have found that a specialist can do it cheaper, faster, and sometimes even better. This Lionel toy crank is an example. GRC specialized techniques made it possible for them to produce this tiny authentic part more quickly and more economically than Lionel could themselves. Die cast in zinc alloy in a single automatic operation, the cost of the GRC crank was little more than $5.00 per thousand in lots of 500,000.

Miniature in size, intricate in shape, the crank has, for example, four subminiature hex nuts measuring .045" across the flats. It is typical of the many small parts problems solved by GRC, who specializes in parts "no bigger than your thumbnail". It is typical too of the close tolerances, clean edges and great accuracy achieved by Gries' methods. Whether simple or complex, quality is uniform—no secondary operations, no scrap loss. GRC delivered parts are ready for immediate use.

The world's foremost producer of small die castings, Gries' exclusive patented methods have resulted in many production economies and give broad flexibility in design. If you have a small parts problem, write for Gries' informative die casting bulletin or send prints for quotations. There is no minimum size; maximum, 1¾" long, ½ oz.

New Gries Bulletin Explains How Movable Multiple Part Units are Cast-Assembled by INTERCAST Method

The unique "intercast" method developed by Gries Reproducer Corporation for cast-assembling in one operation movable multiple part units, as well as continuously interlocked assemblies (such as chains), is explained in a new bulletin. Maximum size for "intercast" parts is 1½" long.

This patented automatic, time-saving, money-saving method is an ingenious refinement of Gries' exclusive method of small parts die casting. Gries' technique of both zinc alloy die casting and plastic molding of tiny parts is well known and has proved of inestimable value in overcoming design limitations and lowering costs. Automatic production assures precise tolerances and uniform quality.

Copies of the bulletin are available from Gries.

GRC Nylon and Other Plastic Molded Parts Accurate and Uniform

Unique, automatic molding techniques developed by Gries Reproducer Corp. permit mass production of nylon and other thermoplastic parts with exceptional accuracy and uniformity. Molding with single cavity techniques, GRC avoids lack of uniformity in size from cavity to cavity, difficulty in matching (flash and off-set at parting line), difficulty in filling. For the ultimate user it means no parts sorting to detect defectives, no selective assembly to compensate for variations, no cleaning operations.

Specializing in tiny parts (their maximum size is 1¼" long, .03 oz. in weight, no minimum), GRC can make quick deliveries on quantities from 50,000 to many millions, and will quote promptly upon receipt of blueprints or specifications. Samples and factual bulletin can be obtained by writing directly to Gries Reproducer Corp. in New Rochelle.

GRC High Series Cap Nuts Now Cataloged In Stock

Never before available to industry as a stock item from any supplier, GRC is now stocking for prompt delivery cap nuts with up to 50% greater thread depth. Immediate shipment can be made on a complete range of hex sizes from 5/16" to ⅝". Die cast in zinc alloy with long, clean thread sections, the overall height of the cap nut is well proportioned between the hexagonal section and the dome of the fastener. Protective, neat and attractive, they are rustproof, corrosion-resistant, non-ferrous, without tool marks or cut-off burrs. They have a naturally bright finish and if required any standard finish can be applied. Other GRC stock fasteners include wing nuts and screws, round head thumb nuts and screws, standard cap nuts, rivets and others. Catalog and spec sheets on the new high series cap nuts and other fastenings are available on request.

WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS

GRIES

GRIES REPRODUCER CORP.

32 Second St., New Rochelle, N. Y. • New Rochelle 3-8600

Be sure to see GRC at the Metal Show BOOTH 1343

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Surface Finishes

Slide chart shows means of obtaining a given surface finish, applications for that finish, and tolerances. It also shows which Profilometer tracer, sidemount, length of trace, piloting, cutoff, and Amplimeter to use in measuring surface roughness. Micrometrical Mfg. Co.

Circle 661 on page 19

Spring Pins

Diverse cost-saving applications for Sel-Lok spring pins—slotted, tubular pins that lock by spring action when driven into holes—are illustrated in Folder 2331. Uses are as fasteners, guide pins, keys, stops, and axles. 4 pages. Standard Pressed Steel Co., Sel-Lok Spring Pin Div.

Circle 662 on page 19

Cold Finished Steel Bars

"Residual Stresses in Cold Finished Steel Bars and Their Effect on Manufactured Parts" is title of pocket-size Bulletin 16. Subjects covered range from stresses in cold drawn, ground, turned, and heat treated steels to fatigue, cracking, machinability, corrosion, and tolerances. 32 pages. La Salle Steel Co.

Circle 663 on page 19

Flexible Coupling

How the Para-flex flexible cushion coupling, by means of its rubber tire element, accommodates angular and parallel misalignment and end float is explained in illustrated Bulletin A-669. It also cushions shock loads and minimizes torsional vibration. 12 pages. Dodge Mfg. Corp.

Circle 664 on page 19

Flat-Die Forging

Facilities and equipment for producing flat-die forged products of high speed, tool, alloy, and stainless steel are described in illustrated folder. Parts up to 4000 lb can be turned out. Smith-Armstrong Forge, Inc.

Circle 665 on page 19

Magnetic Drive

Ampli-Speed magnetic drive discussed in illustrated Data Sheet 4400-PRD-243 is an eddy current clutch device which provides alternating current speed changing as well as automatic speed control. It has a 10 to 310 hp range. Detailed specifications are given. 2 pages. Electric Machinery Mfg. Co

Circle 666 on page 19

Wire Clamps

Fast means of securing wires in aircraft, missile, and electronic assemblies is described in folder on nylon wire clamps. Details of application, holding power, and quick modification are given. 4 pages. Dakota Engineering, Inc.

Circle 667 on page 19

Stainless Steel Strip

Important properties of hardenable types of 300 series of ultra thin and high precision tolerance stainless steel strip are outlined in data sheet. Hardening is by subzero and precipitation processes. Data on 200 series alloys are also presented. American Silver Co.

Circle 668 on page 19

Powder Metallurgy

"Product Improvement Through Powder Metallurgy" is title of Bulletin M-2057 which describes copper and brass, iron and steel, silver and its alloys, and tungsten materials used in the process. Characteristics of each are given, along with examples. 4 pages. Superior Carbon Products, Inc.

Circle 669 on page 19

Screw Machine Products

How to cut costs on screw machine products is one of subjects covered in illustrated brochure. Plant facilities are shown and different styles and applications of parts produced are pictured. 12 pages. J. J. Tourek Mfg. Co.

Circle 670 on page 19

Servo-Mechanical Parts

Line of miniature and standard parts for prototype and production servomechanisms is described and illustrated in catalog. Specifications for gears, mounting plates, shaft hangers, dial assemblies, couplings, and other parts are included. 32 pages. Reeves Instrument Corp.

Circle 671 on page 19

Hard Bright Gold

Printed circuitry, variable resistors, terminals, and contacts are applications for hard bright gold, data on which are presented in folder. It has a wide operating range and contains almost no free cyanide. Operating and other data are presented. 4 pages. Technic Inc.

Circle 672 on page 19

Steel Tubing

Some of the many uses of seamless and electric resistance steel tubing in materials handling equipment are depicted in illustrated Booklet IA-6. 12 pages. Copperweld Steel Co., Ohio Seamless Tube Div.

Circle 673 on page 19

Modular Actuators

Sixty-four standard interchangeable modular actuator components which can be assembled into hundreds of combinations are illustrated and described in Catalog 57A. Three operating capacities are up to 350, 2500, and 3500 lb. Table gives operating and ultimate static load for screw jacks. 4 pages. Airborne Accessories Corp.

Circle 674 on page 19

Nylon Parts

Case histories designed to assist engineers in applying nylon parts in their industries are contained in set of application literature. Information on chemical, electrical, machine tool, food, textile, instrument, and other fields are included. Polymer Corp. of Pennsylvania.

Circle 675 on page 19

Resistors

Long term load and shelf stability, low noise level, and full rating at 150° C are features of Riteohm Series 77 metal film resistors, subject of illustrated Bulletin 155. Characteristics compared with MIL specifications, dimensions, and other data are included. 4 pages. Ohmite Mfg. Co.

Circle 676 on page 19

Valve Indicator

Capswitch valve position indicator automatically signals a control board apparatus when an opening or closing cycle is completed. Subject of illustrated data sheet, the unit is described in detail and its specifications given. 2 pages. Robertshaw-Fulton Controls Co., Bridgeport Thermostat Div.

Circle 677 on page 19

Double Pumps

Series QGH-H double pumps described in illustrated Catalog Section G-114 consist of two Gerotor 2000-psi cartridges mounted on a common assembly. Also described are valve panels for high-low, two-pressure, or separate systems. Specifications of both units are included. 4 pages. Gerotor May Corp.

Circle 678 on page 19

V-Belting

Regular and oil-resistant neoprene Thoro-Link V-belting for machine drives is described in illustrated Form 2156. Sizes, types, ratings, horsepower ratings, measuring, and assembly-disassembly data are included. 4 pages. Dayton Rubber Co.

Circle 679 on page 19

Silicone Rubber

Electrical insulating advantages of Silastic silicone rubber are outlined in Brochure 9-105. Included is a tabular summary of dielectric properties of typical stocks at temperatures

only circuit breakers
protect continuity
in automation

fewer power stoppages...
faster restarts...
guard production levels

circuit breaker protection is sure and accurate

YOU CAN BE SURE...IF IT'S Westinghouse

TIME CLOCKS DON'T STOP WHEN YOUR LINE IS "DOWN"

by H. D. Dorfman
Westinghouse Electric Corporation

Automation brings many new considerations to the maintenance of electrical systems for production plants. A pertinent example is the increasing importance of engineered protective devices.

A great deal more than ampere load supervision is required to protect electrical circuits serving automatic production units. Mobile assembly lines, interlocked with sub-assembly and component feeder carriers, represent a cost per minute that makes insurance against stoppage very important. That is why those of us concerned with the production of circuit protective equipment "harp" on the advantages of circuit breakers. Two of the cost-saving features are:

- *Prevention of power interruption resulting from harmless, temporary current surges.
- *Speed in restoration of power after an interruption.

Breakers More Accurate

Breakers avoid false stoppages in many ways. One is accurate calibration. There is a correct breaker for each particular current load and environmental condition. Exacting tests at our plant insure its being right before delivery.

Where temperature variations affect breaker ratings, but not conductor ratings, ambient-compensated breakers should be specified as additional insurance against current interruptions due to false temperature influences.

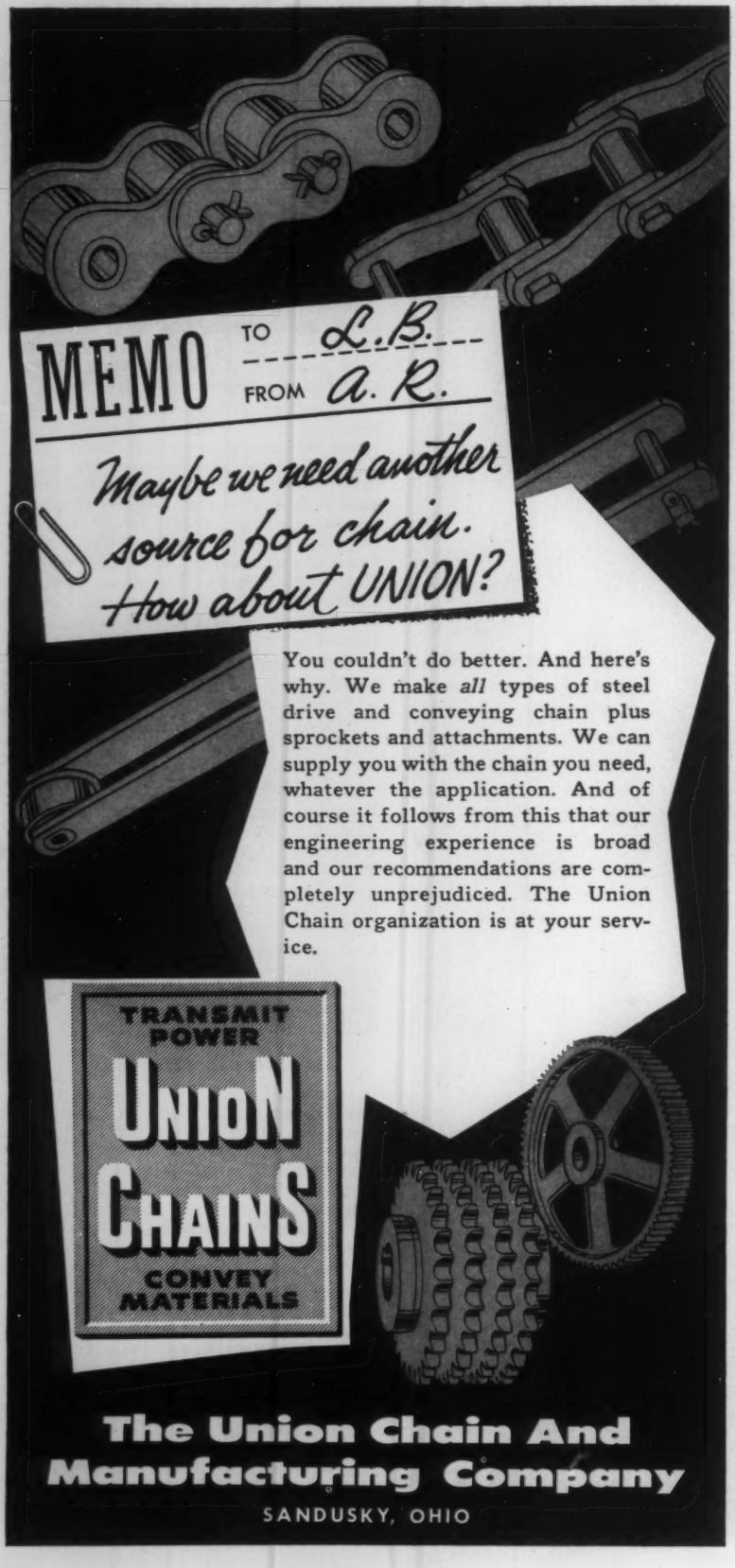
Breakers Increase Safety

In speed of restoring power, breaker advantages are obvious. A "tripped" breaker is immediately identified by the position of its handle. A quick flip of that handle restarts production in seconds. If a fault persists, the breaker reacts again to protect the circuit. It's all done with complete safety to the operator.

Fuse hunting, on the other hand, can be costly in accumulated man-machine-time. Locate the blown fuse... remove it... find the right replacement (still not as accurately calibrated as a breaker) ... insert it... close switch. No matter how well organized your electrical maintenance crew, time is lost.

Unfortunately, the time clock does not stop ticking off the cost just because payload is cut off. Thus, the more complete your automation, the more important your need for real protection of its continuity with circuit breakers. J-30274

Circle 489 on page 19


MEMO TO L.B.
FROM A.R.
Maybe we need another source for chain. How about UNION?
You couldn't do better. And here's why. We make all types of steel drive and conveying chain plus sprockets and attachments. We can supply you with the chain you need, whatever the application. And of course it follows from this that our engineering experience is broad and our recommendations are completely unprejudiced. The Union Chain organization is at your service.
TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS
The Union Chain And Manufacturing Company
SANDUSKY, OHIO

Helpful Literature

from 25 to 250° C. Section is devoted to type for encapsulating and potting. 4 pages. Dow Corning Corp.

Circle 680 on page 19

Metal Stampings

Facilities for producing metal stampings in small lots from a maximum blank size of 22 x 22 in. are outlined in Bulletin F-185. Stocked metals available are listed, typical stamping examples are shown, and four examples of short run production costs are given. 8 pages. Dayton Rogers Mfg. Co.

Circle 681 on page 19

Solderless Terminals

"Solderless Terminals for the Railroad Industry" is an illustrated brochure which describes and illustrates terminals for locomotives, rolling stock, and signal wiring. Hand tooling is shown. 24 pages. AMP Inc.

Circle 682 on page 19

Speed Control

Full load torque is available at all speeds with the Rev-O-Trol stepless speed control, described in illustrated Bulletin R-313. Unit converts alternating current for direct current motor drive. Specifications and application data are included. 4 pages. Acme Electric Corp.

Circle 683 on page 19

Shock Tester

Accurate simulation of shock experienced by equipment in actual use is provided by the Hyge shock tester, described and illustrated in Bulletin 4-70. It can produce thrusts up to 12,000 lb instantaneously with precision waveform control. 12 pages. Consolidated Electrodynamics Corp., Rochester Div.

Circle 684 on page 19

Hubs & Bushings

Specifications for steel hubs for split taper bushings and malleable split taper bushings are found in illustrated Price Sheet HB-101-A. Dimensional drawings are included and a few applications are shown. 4 pages. Browning Mfg. Co.

Circle 685 on page 19

Gear Production

Facilities for gear cutting, gear tooth grinding, thread and worm grinding, heat treating, grinding (cylindrical, internal, surface, and centerless), deep hole drilling, servo motor reduction units, and control gear and gear train manufacturing are outlined in illustrated Bulletin 431. Norden-Ketay Corp., Florida Gear Div.

Circle 686 on page 19

Lock Screws

Principles and advantages of Spin-Lock screws are detailed in Folder 557C. The one-piece fastener features a ratchet-like element which grips the work securely. 4 pages. Pittsburgh Screw & Bolt Corp.

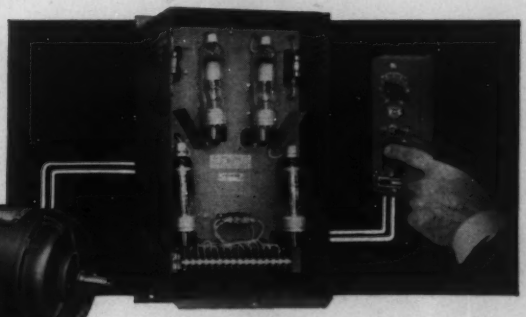
Circle 687 on page 19

Hard-Facing Alloys

Revised issue of "Haynes Hard-Facing Alloys in Coils" describes the chemical composition, some proper-

New!

RELIANCE V*S Jr.



All Electric
Variable Speed Drive
with Finger-tip Control

The new V*S Jr. gives you instantaneous speed changes, even under load, without belts, pulleys, or gears. This Reliance Drive puts complete machine control at the operator's fingertips. All functions, jog, start, stop, reverse and speed changes are placed in a compact, remote control station.

The 8 to 1 motor speed ratio puts extra flexibility into your machinery. Speeds may be changed through this wide range as frequently as required. The motor will operate through a 100 to 1 speed range for jogging or light intermittent duty.

There's a big power cushion in the motor too . . . power for smooth speed pick up, even under heavy shock loads, and dynamic braking for fast controlled stops without shuddering or jerking.

The Reliance V*S Jr. is your answer to machinery drive problems in the ¾ to 4 horsepower range. Package construction makes installation easy; just plug it in to a single phase 220 or 440 volt a-c. line.

Write for Bulletin D-2505 for complete details. D-1554

RELIANCE ELECTRIC
AND ENGINEERING COMPANY
Dept. 2810A, CLEVELAND 17, OHIO
CANADIAN DIVISION: WELLAND, ONTARIO
Sales Offices and Distributors in principal cities

Circle 491 on page 19

MIDLAND
WELDING NUTS

take seconds to apply... save hours of labor!

If you make a component part of an ultimate metal assembling operation requiring bolting in hard-to-get-at places, Midland Welding Nuts may well be the answer to simple, secure fastening later on. The practical Midland method anchors the nut in the exact location, ready to receive the bolt. There's no guesswork and cross-threading becomes impossible.

It's easy to apply Midland Welding Nuts.

Just insert the collar in the hole for bolt or screw, resistance-weld the nut in place, and the nut is anchored for the life of the job. Nuts can be automatically fed to the welder to save time.

Midland Welding Nuts assure close fit of metal parts. They can't work loose, causing annoying rattles. Also, parts can be removed easily and quickly for replacement or repair without threat of losing nuts. Assembly workers prefer them because they turn stubborn, difficult jobs into simple, easy to handle projects, often converting two-man tasks into one-man operations.

Write or phone for complete information!

The MIDLAND STEEL PRODUCTS COMPANY

6660 Mt. Elliott Avenue • Detroit 11, Michigan

Export Department: 38 Pearl St., New York, N. Y.

AUTOMOBILE and TRUCK FRAMES • AIR and VACUUM POWER BRAKES

AIR and ELECTRO-PNEUMATIC DOOR CONTROLS

Helpful Literature

ties, typical applications, and application procedures for six iron-base alloys produced in drawn tube rod form and for Haystellite cast tungsten carbide rod. 8 pages. Haynes Stellite Co.

Circle 688 on page 19

Neutron Shielding

Boral, a mixture of boron carbide and aluminum rolled into ⅛ or ¼-in. thick sheets, is produced for neutron shielding in atomic power installations. Its composition, uses, and properties are given in folder. 4 pages. Brooks & Perkins Inc.

Circle 689 on page 19

Microfilm Drawing System

The comprehensive Recordak microfilm system for duplicating, filing, and safeguarding engineering drawings is subject of Folder No. R1-22. How system works for both the large and small company is pointed up. 8 pages. Recordak Corp.

Circle 690 on page 19

Magnetic Drives

Whitney-Tormag magnetic drives in 1 to 15 hp ratings are described as to features, operating curve, output torque, dimensions and selection in Bulletin W-T. Typical installations are shown. Operating torques range from 3 to 45 lb-ft. 6 pages. Whitney Chain Co.

Circle 691 on page 19

DC Power Supplies

Custom-built dc power supplies described in Bulletin GEA-6690 are used for computer, aircraft, military, and special applications. Folder provides chart citing relative characteristics of various units and includes basic electrical and mechanical details. 6 pages. General Electric Co.

Circle 692 on page 19

Servo Amplifiers

Performance characteristics of production models of the 60 and 400 cps transistor servo amplifiers are provided in Bulletin 1800. Miniaturized units can provide up to 9 w controlled power at weight factor of less than 1 oz per watt. 4 pages. M. Ten Bosch, Inc.

Circle 693 on page 19

Blind Rivets

Application data on drive-pin blind rivets are given in Bulletin DF-3 along with dimensional drawings on all sizes. Rivets are designed for special blind, or limited-clearance applications in the fabrication of thin-winged jets and supersonic missiles. 16 pages. Deutsch Fastener Corp.

Circle 694 on page 19

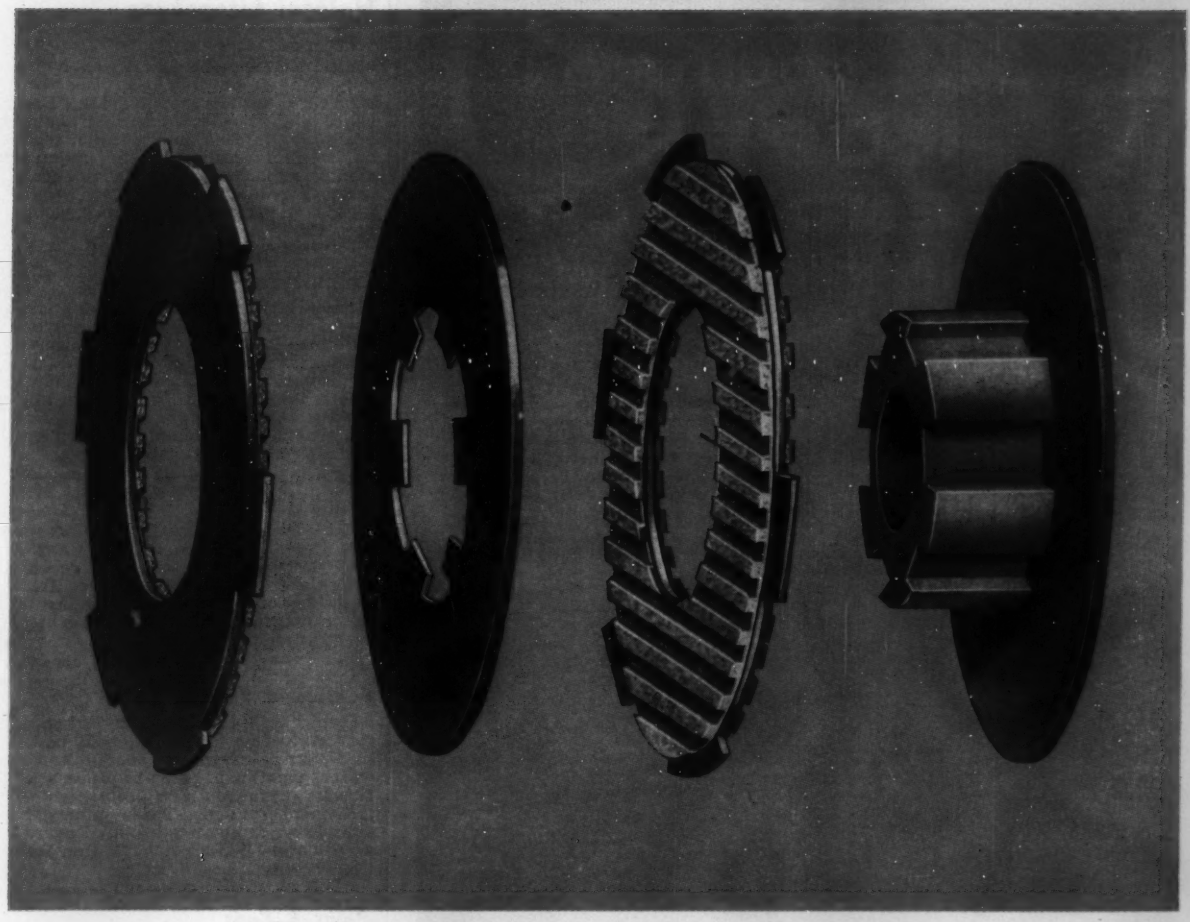
DC Voltage Standard

DC Standard Bulletin 15-3 describes the Kin Tel model 301 variable direct-current standard and null voltmeter. Unit measures voltages from 1 to 501 v and has four decaded null meter ranges from 50 v to 50 mv full scale. 2 pages. Kin Tel.

Circle 695 on page 19

Expandable Polystyrene

Dylite expandable polystyrene is a compact, free-flowing granulated



Armstrong RESILIENT FACINGS...

Simplify design, extend service life in appliance clutches

Three resilient facings do the work of eight metallic friction surfaces in this re-designed automatic washer clutch. This simplified design cut production costs while maintaining the torque capacity of the original clutch. It also eliminated what had been a major source of customer complaints.

The improved clutch is built around NC-733, one of many resilient materials in the Armstrong line. This compound's high coefficient of friction made it possible to reduce the number of clutch plates and, at the same time, improve operating characteristics.

The switch to NC-733 solved a production and maintenance problem as well. The old clutch with metal plates required a half-hour break-in period plus a drain and refill operation. In spite of this precaution, metal particles continued to damage gears and facings, causing failure in service.

Now, the use of resilient facings has cut out the break-in run and, more important, the facings last the life of the appliance—without field maintenance.

Armstrong resilient facings have cut costs and improved performance in hundreds of applications, both wet and dry. If you have a problem involving friction materials, let us put our years of experience to work for you.

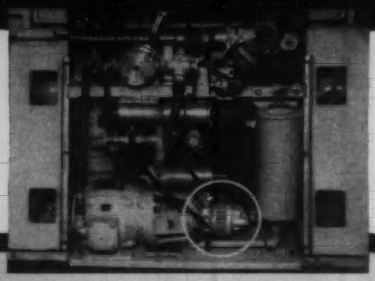
A new booklet describing the complete line of Armstrong friction materials will be available shortly. Write in today and reserve your copy. Armstrong Cork Company, Industrial Division, 7211 Ithaca St., Lancaster, Penna.

Armstrong RESILIENT FRICTION MATERIALS

... used wherever performance counts

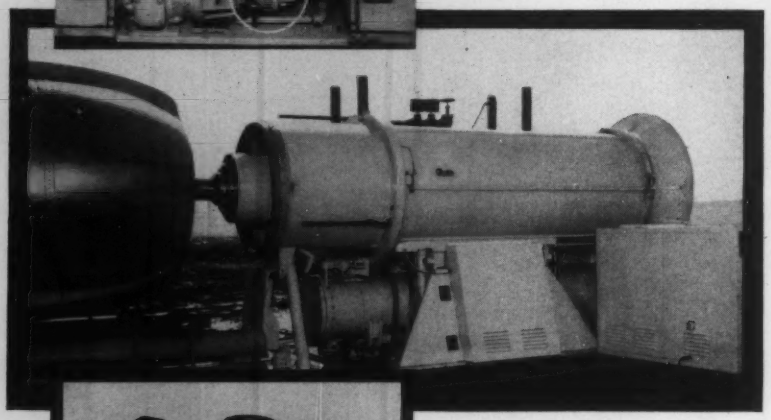
TWA COUNTS ON ROPER DEPENDABILITY

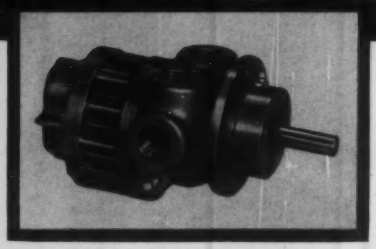
for Efficient Operation of Engine Test Stand



NERVE CENTER OF THE UNIT

Oil used as the power absorption medium in this dynamometer is supplied to the inlet control valve by a Roper Series F Pump. Four other Roper pumps are integral for pressure lubrication and hydraulic actuation of this unit.





ROPER SERIES F PUMP

1-300 GPM • TO 300 PSI

This 5000 HP Absorption Dynamometer, one of five specially designed for TWA by Clayton Mfg. Co., El Monte, California, is the newest concept of aircraft engine testing and run-in. Its use is based on a principle of power absorption, and thus replaces the club propeller used on conventional test stands. The unit is proved to be a quicker, more accurate means of testing than has been previously available. Standard Roper Series F Pumps were specified by Clayton for inclusion in the nerve center of the unit. It is another example where design men call upon Roper because they know of Roper dependability.

Send for Catalog or See it in Sweets

GEO. D. ROPER CORPORATION
250 Blackhawk Park Avenue
Rockford, Illinois

ROPER Rotary Pumps

Helpful Literature

plastic that can be foamed by application of heat into a closed cell structure with a tough skin. Brochure C-6-204 describes many uses and provides data on expansion techniques, mold design, heating requirements, molding cycles, steam accessories for molding, adhesives, coatings, and storage. 34 pages. Koppers Co.

Circle 696 on page 19

Exhaust Purifiers

Exhaust purifiers for oxidizing carbon monoxide, fumes and odors from gasoline, LP-gas and diesel-powered equipment are illustrated and described in folder entitled "Exhaust Fumes Are Poison." Fork trucks, stationary engines, power sweepers, and construction equipment are applications. 4 pages. Oxy-Catalyst, Inc.

Circle 697 on page 19

Steam Traps

Quik-Flex thermostatic steam traps descriptively covered in Bulletin 257 are designed for outdoor service where a freezeproof trap is required. Specifications, capacities, and installation diagram are provided. 4 pages. V. D. Anderson Co.

Circle 698 on page 19

Controlled Volume Pumps

Typical applications for H20 controlled volume pumps include boiler feed water treatment, cooling tower water treatment, feed-to-process of various chemicals, and process water treatment systems. These pumps, in simplex or duplex models are covered in Bulletin 557. 4 pages. Milton Roy Co.

Circle 699 on page 19

Plugs & Caps

Specifications provided in Catalog 57-4 on Shurclose caps and plugs cover seven styles of both rubber and plastic types. These closures are used to protect, seal or mask threaded parts, pipe ends, or tubing. 4 pages. Shurclose Seal Co.

Circle 700 on page 19

Impact Wrench Calibrator

Performance characteristics of an impact wrench calibrator and tensile tester in checking threaded fastener strength, testing of power wrenches, and in setting assembly torque standards are given in brochure. Ultimate strengths of screws in 10-24 to 1¼-12 sizes are featured. 4 pages. Skidmore-Wilhelm Mfg. Co.

Circle 701 on page 19

Metals Analysis & Testing

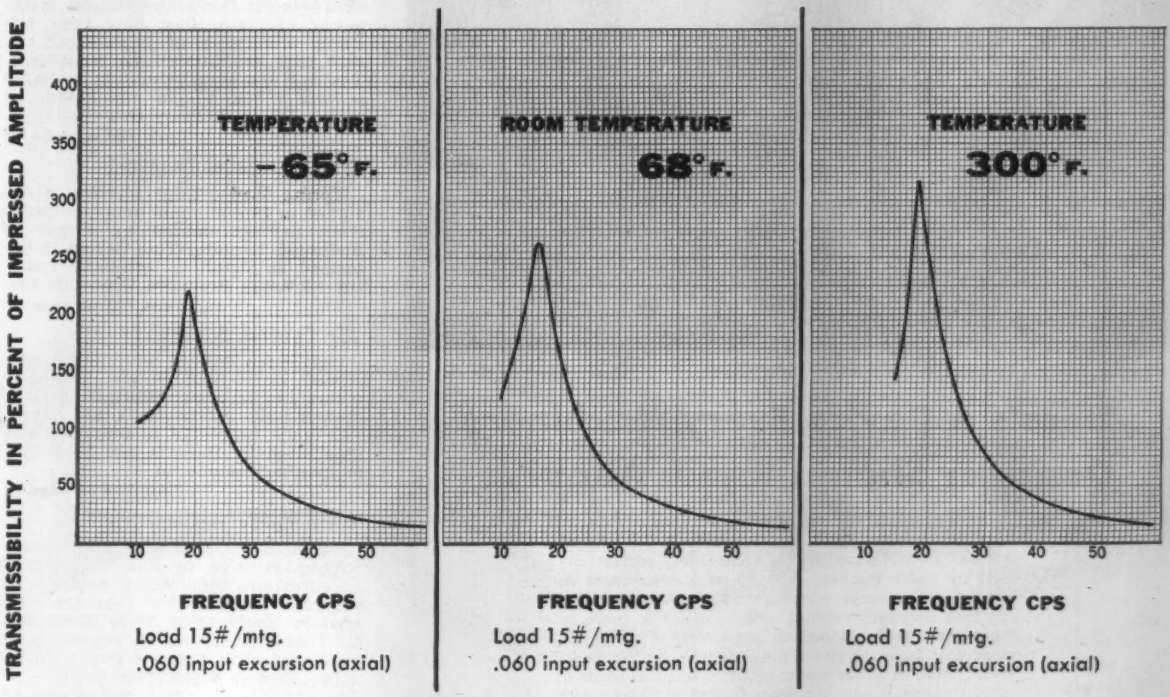
Bulletin 13 lists cost for performing chemical analyses of metals, alloys, and ores on a per single sample basis. Costs for individual physical tests as well as comprehensive testing service are listed. 4 pages. Crippen & Erlich Laboratories, Inc.

Circle 702 on page 19

Blind Rivets

Detailed specifications on Star Pin-Grip mechanically expanding metal-to-metal blind rivets are given in booklet. Typical applications include fastening of metal sheathing to

Broad Temperature Range elastomers for LORD bonded rubber mountings



BROAD TEMPERATURE RANGE — Transmissibility curves for LORD Mounting with new type *BTR* elastomer indicate that temperature extremes produce minimum change in physical properties. Transmissibility at resonance is three or less at 68°F. or lower temperatures, and 3.5 or less at 300°F.

■ A new type Broad Temperature Range elastomer with resistance to temperature extremes is now available from LORD Manufacturing Co.

This new material is used in performance-proved LORD mounting designs to assure superior vibration isolation under severe environmental conditions. It is resistant to oil and ozone, and functions efficiently in temperature ranges from −65°F. to 300°F. Its proven mechanical properties include high tensile strength, high tear resistance, and good flex life. The hysteresis characteristic of the material eliminates the need for auxiliary dampers, which generate harmonics destructive to mounted equipment.

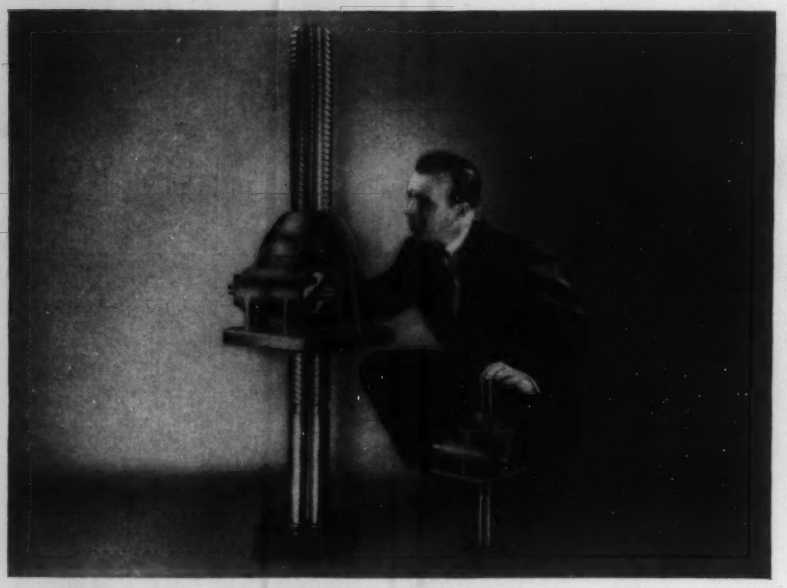
For further information on this new elastomer, contact your nearest LORD field engineer or the Home Office, Erie, Pa.

ATLANTA, GEORGIA · CEdar 7-1123
BOSTON, MASS. · HAncock 6-9135
CHICAGO, ILL. · Michigan 2-6010
CLEVELAND, OHIO · SHadyside 9-3175
DALLAS, TEXAS · Riverside 1-3392
DAYTON, OHIO · Michigan 8871
DETROIT, MICH. · TRinity 4-2060
KANSAS CITY, MO. · WEstport 1-0138
LOS ANGELES, CAL. · HOllywood 4-7593
NEW YORK, N. Y. · Circle 7-3326
PHILADELPHIA, PA. · LOcust 4-0147
"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY · ERIE, PA.

LORD BONDED RUBBER

designers and producers of bonded rubber products since 1924



Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 6¾:1 to 32:1; turn of worm for each 1-inch raise, 10 to 48; available in either Acme or square threads. For protection against foreign matter certain models can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—adjusting welding positioners.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes. For complete specifications and detailed drawings, send for your free copy of a special brochure.

DUFF-NORTON Company

DUFF-NORTON COMPANY
Department MD
P.O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

NAME _____ TITLE _____

COMPANY _____ PHONE _____

ADDRESS _____

Helpful Literature

framework of trucks and buses, securing plywood to metal framework, and assembly of metal furniture. 8 pages. Star Expansion Industries, Inc.

Circle 703 on page 19

Sintered Metal Parts

Booklet No. 1-457 points up advantages of Sintaloy powder metal parts, and describes how they are made. Principles of economical design and production are considered. Typical characteristics of available powder metal alloys are listed. 12 pages. Dixon Sintaloy Inc.

Circle 704 on page 19

Pressure Gage Isolator

Spring loaded gage isolator is designed to protect fluid pressure gages from damage caused by surges in hydraulic circuits. This device is described in detail in company bulletin. Sarasota Precision Products, Inc.

Circle 705 on page 19

Air Control Equipment

Complete line of new and redesigned air control devices, including filters, regulators, lubricators, dehumidifiers, automatic drain traps, and quick couplings, is described and illustrated in Bulletin 80. 12 pages. Perfecting Service Co.

Circle 706 on page 19

Time Delay Relays

Applications, operation, and specifications relative to line of military specification time delay relays and sequence program switches are covered in Engineering Data Sheet No. 5. Timer is offered in repeat cycle and reset cycle types. 4 pages. Automatic Timing & Controls, Inc.

Circle 707 on page 19

Rotary Switches

Physical features, as well as standard and general performance characteristics are provided on IDL high speed rotary switches in bulletin. Switches are available for 45 contacts at 20 rps, 90 contacts at 10 rps, and 30 contacts at 30 rps. 2 pages. Instrument Development Laboratories Inc.

Circle 708 on page 19

Laminating Resins

Technical Bulletin T-21 presents information on Hysol resins used in combination with glass cloth for producing dimensionally stable laminates at contact pressure. Bulletin covers uses, materials, physical properties, and fixture and tool manufacture. Houghton Laboratories Inc.

Circle 709 on page 19

Welding Electrodes

Information essential to anyone concerned with buying or using electrodes is provided in Electrode Pocket Guide. An electrode consumption calculator aids in calculating consumption per linear foot in the welding of various types of joints. 70 pages. Air Reduction Co.

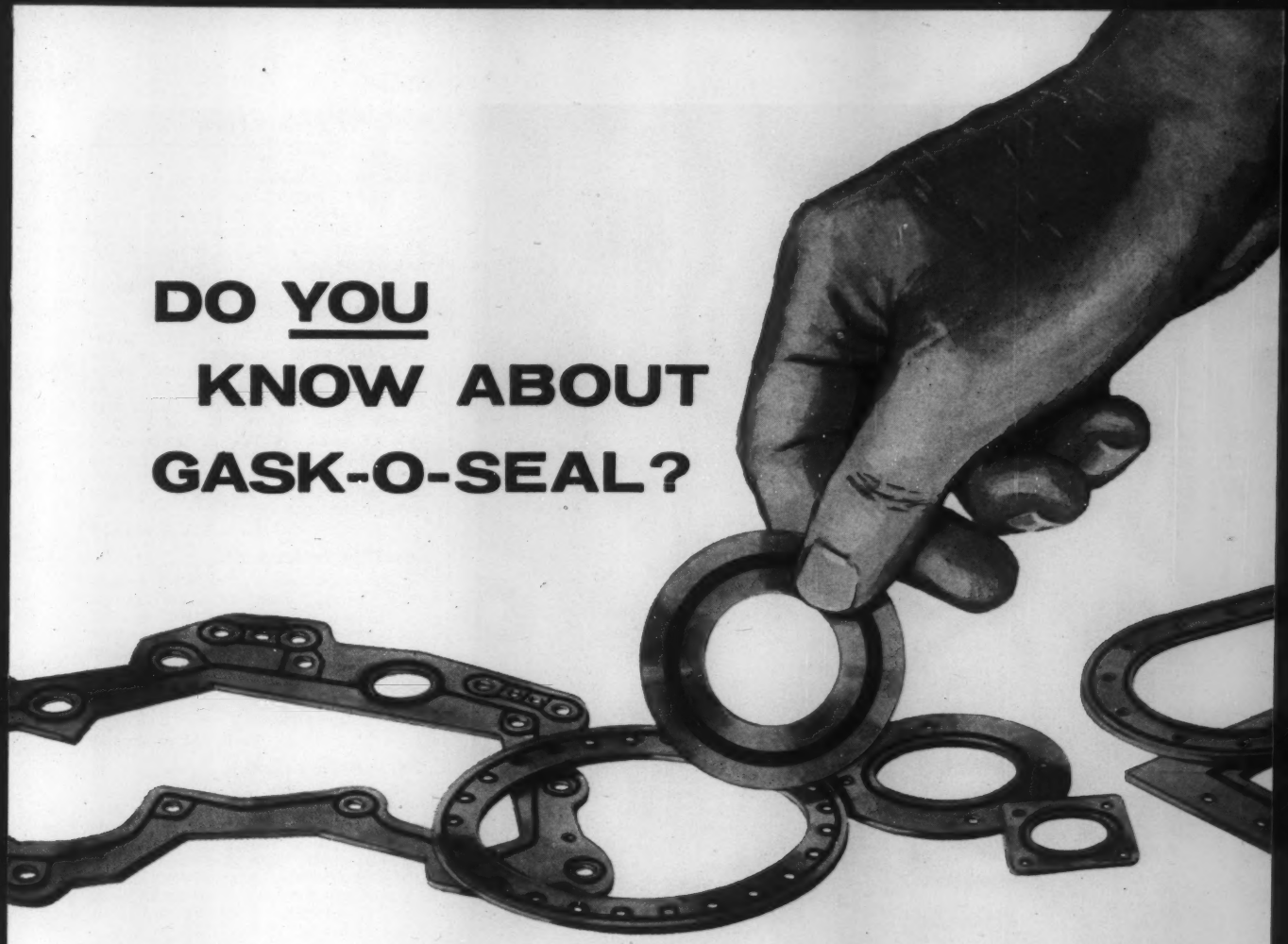
Circle 710 on page 19

Interval Measurement

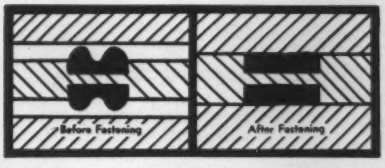
Data File 112 discusses "Time Interval Measurements and How to Make Them." Subjects covered in-

Circle 496 on page 19

DO YOU KNOW ABOUT GASK-O-SEAL?



The static seal that can not blow out!



The above diagram is "typical" only. Gask-O-Seals are also made with one-side seals.

If you do not know about Gask-O-Seals look at these facts:

- Gask-O-Seals will seal practically any processable fluid . . .
- Gask-O-Seals can be re-used . . .
- Gask-O-Seals will seal at low or high pressures, vacuum or positive . . .
- Gask-O-Seals are available as standards and as specials in almost any configuration or to meet special requirements.

They are recommended for flanges, gear boxes, transfer cases . . . any place where truly efficient static seals are needed.

Note: A recent development of the Gask-O-Seal principle indicates effective sealing in the temperature ranges of −400° to +1000° for specific applications.

®—the O-Seal family:
Lock-O-Seal®
Gask-O-Seal®
Stat-O-Seal®
Bolt-O-Seal®
Riv-O-Seal®
Banj-O-Seal®
Termin-O-Seal®

FRANKLIN C. WOLFE CO.
Culver City, California
"sealing design specialists"
A DIVISION OF Parker APPLIANCE COMPANY
Hydraulic and fluid system components

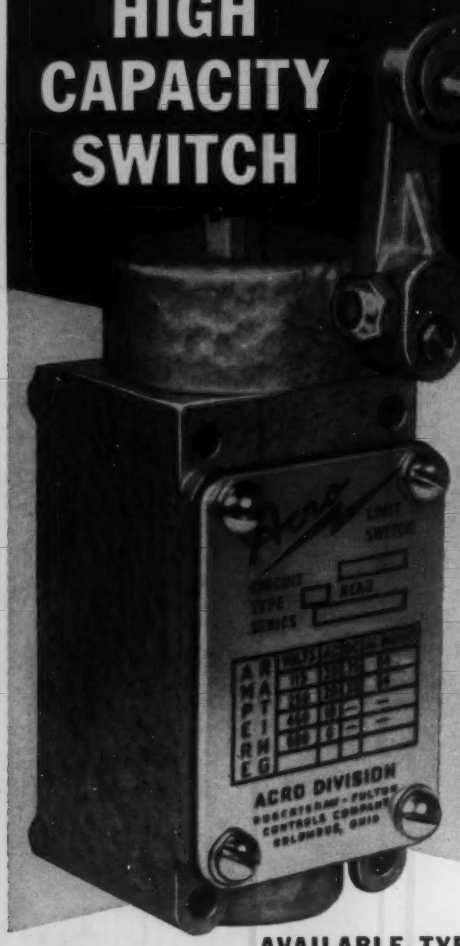
Circle 497 on page 19

HIGH CAPACITY SWITCH

Controls up to 4 circuits

•

DUST, OIL-TIGHT
LONG LIFE
VERSATILE
LONG OVERTRAVEL



Machine tool and other equipment applications are "naturals" for this Acro high capacity switch, which can control up to four separate circuits on either pilot or line duty. Actuator is adjustable 360° in two planes.

ELECTRICAL RATING

2 H.P. 230 Volts A.C.
1 H.P. 115 Volts A.C.
20 Amps—250 Volts A.C.

Two types available: Double Action Type actuates switch contacts when actuator is moved either side of "at rest" position. Single Action Type operates from one side of "at rest" position only. Both are designed for long life under heavy use.

AVAILABLE TYPES

Catalog No.	Circuit Arrangement	No. Terminals	Action
242-0003-03	Four circuits (two open, two closed)	8	Double
242-0011-03	Four circuits (two open, two closed)	8	Single
242-0010-03	Double circuit (one closed, one open)	4	Double
242-0012-03	Double circuit (one closed, one open)	4	Single
242-0019-03	Double circuit (normally closed)	4	Double
242-0017-03	Double circuit (normally closed)	4	Single
242-0020-03	Double circuit (normally open)	4	Double
242-0018-03	Double circuit (normally open)	4	Single

Write for complete information and application engineering help. Mention ACRO Machine Tool Switch!

Mr. Controls

Robertshaw-Fulton
CONTROLS COMPANY

ACRO DIVISION • Columbus 16, Ohio

In Canada: Robertshaw-Fulton Controls (Canada) Ltd., Toronto

Helpful Literature

clude time interval meters, measuring pulse width and elapsed time, low frequency period measurements, timing relay operations, and measuring velocity. 10 pages. Beckman Instruments, Inc.

Circle 711 on page 19

Arc Welding

Revised Bulletin W-17, with up-to-date technical information on arc welding with bronze electrodes, filler rod, and wire, includes data on Ampco-Trode 40 electrode and new Ampco Braz No. 1, 2, and 3 filler rods. Covered are welding procedures, techniques and processes, recommended welding currents, and typical applications. 24 pages. Ampco Metal, Inc.

Circle 712 on page 19

Counting Instruments

Condensed catalog of PIC endurance rated counting instruments shows heavy duty electric, stroke, and revolution counters; electric counter actuators; small electric and stroke counters; coil winding counters; and automatic batch counters. 4 pages. General Controls Co., Production Instruments Div.

Circle 713 on page 19

Refrigeration Tubing

How this company serves the refrigeration industry in the manufacture of copper and aluminum tubing and tubular products is related in Bulletin 5805. Mill facilities and a few end products are shown. Tubing sizes range from 0.062 in. to 4.500 in. OD. 12 pages. Calumet & Hecla, Inc., Wolverine Tube Div.

Circle 714 on page 19

Case-Hardened Steel

Rycase free-machining, high manganese, carburizing steel provides a hard, uniform, deep case; a tough, ductile core with high properties; and superior machinability. Revised Technical Bulletin 14-8 describes steel's properties and lists comparative strength figures. 4 pages. Joseph T. Ryerson & Son, Inc.

Circle 715 on page 19

Segment Socket

Aeroquip segment socket described in Marine Engineering Bulletin is designed for use with areoquip medium and high pressure hoses, and is available in sizes ranging from 2 to 6 in. ID. Bulletin gives dimensional and operating data. 2 pages. Aeroquip Corp.

Circle 716 on page 19

DC Motors & Generators

Described in Catalog No. SP-182 are direct current motors and generators with ratings from ½ to 200 hp and ¾ to 200 kw. Applications in typical industries are shown. Marathon Electric Mfg. Corp.

Circle 717 on page 19

Carbon Products

Such properties as machinability, self-lubrication, and nonabrasive and nonsticking qualities are inherent in carbon products for the glass industry described in Carboneering Bulletin AB. Key features for several

As a supplier of welded rings and components to major United States jet engine manufacturers, American Welding has proven its skill as part of an industry where cost and precision are vital factors. As the missile and rocket programs grow from the experimental to the production stage, Amweld's experience and skill can play a part in these essential programs.

If you have a problem that can be solved by a rolled and welded ring or component, or any welded fabrication, contact American Welding's Industrial Products Division. Their skill, experience, and engineering are at your service.

THE AMERICAN WELDING & MANUFACTURING COMPANY
130 DIETZ ROAD WARREN, OHIO

AMERICAN WELDING
The World's Leading Manufacturer of Welded Rings

with
BIJUR
AUTOMATIC LUBRICATION

Bijur Automatic Lubricating Systems designed into your machines *from the start* help you build an early lead in customer satisfaction.

And with Bijur you are *right* because for a quarter of a century Bijur Automatic Lubricating Systems have been part of efficient production programs.

Your customers prefer automatic lubrication in the equipment they buy because it increases production and reduces operating costs. Built into your original plans for machinery production, a Bijur Automatic Lubricating System can work for you by increasing customer acceptance, assuring bearing safety, and contributing to operating efficiency.

Call in a Bijur lubrication engineer. He is ready to help with your technical problems.

6-9

1034

BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

Helpful Literature

grades are listed. 4 pages. Speer Carbon Co.

Circle 718 on page 19

Terminal Blocks

Line of heavy duty Controlead terminal blocks is subject of descriptive Catalog-Folder No. SB-160. Included are illustrations of each type with series number and specifications. Marathon Electric Mfg. Corp.

Circle 719 on page 19

Switches

Complete specifications on rotary, slide, and lever switches for handling power ranging from microwatts to a kilowatt are included in illustrated catalog entitled "Manufacturer's Switches." 35 pages. Globe-Union Inc., Centralab Div.

Circle 720 on page 19

Spring Washers

Designed to facilitate the specifying of standard-size spring washers, illustrated bulletin lists dimensions of dies that are on hand for making flat, curved, Belleville, cupped, slotted, and wavy spring washers. Sizes range from 0.125 to 4.735-in. OD. Available die sizes for making multiple-finger loading springs and wavy spring washers for preloading ball bearings are listed also. 6 pages. Wallace Barnes Co.

Circle 721 on page 19

Whiteprint Machine

Details of a new low-cost volume producing whiteprint machine, the Ozalid Streamliner 400, are given in Bulletin 400. This machine will reproduce from drawings, forms, and other copy of any length and up to 42 in. wide, and will turn out work at up to 24 fpm. General Aniline & Film Corp., Ozalid Div.

Circle 722 on page 19

V-Belts

How Vibrasorb fractional horsepower V-belts reduce vibration and noise by absorbing it before it reaches the machine is explained in Catalog Sheet No. 1800. 2 pages. B. F. Goodrich Industrial Products Co.

Circle 723 on page 19

Stainless Steels

Detailed in Bulletin P.O.2557 are corrosion resistance, strength, workability, hardenability at low heat treating temperatures, and other properties of 17-4 PH and 17-7 PH stainless steels. Typical applications are listed, also. 4 pages. Armco Steel Corp.

Circle 724 on page 19

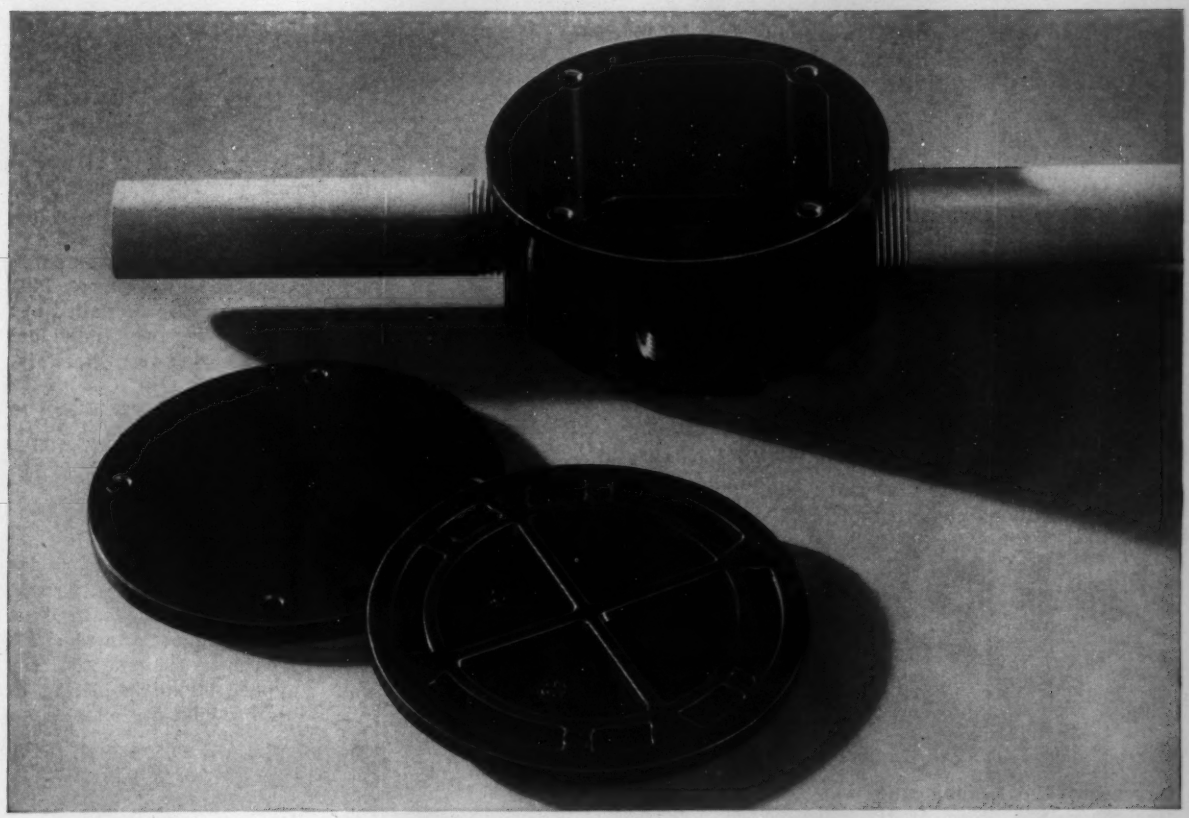
Production Facilities

Illustrated file folder "Some Facts About the Marquette Division" describes engineering and manufacturing facilities of this company. Included are bulletins on typical precision parts and assemblies made to specifications, and on ball and sleeve bearing overrunning clutches for torque loads to 3000 lb-ft. 12 pages. Curtiss-Wright Corp., Marquette Metal Products Div.

Circle 725 on page 19

If one of many requirements is

IMPACT STRENGTH



...get the others too with DUREZ PHENOLICS

Here is another example of how engineering with Durez phenolic plastics created a product that serves better...sells better...costs no more and often less than the one it replaces.

Impact resistance was high on the list of properties required by Union Insulating Co. in designing a non-corrosive conduit junction box for hospitals, chemical plants, and other industrial services. The material to be used also had to be tough, free from warp, dimensionally stable, and light in weight. It had to resist heat, oil, grease, moisture—and corrosion-laden atmospheres. Electrical properties had to meet modern industrial requirements.

Durez checked okay on all counts, Union design engineers found. Specified for its molded AO-4 boxes, Durez results in a superior product at no greater production cost. Customers go for its longer service and reduced maintenance.

The advantages your products could gain with these most widely used phenolics merit investigation. Talk your needs over with your molder... or let us send you engineering data on Durez.

DUREZ®

Plastics that Fit the Job

DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY

510 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICALS PLASTICS

Circle 501 on page 19

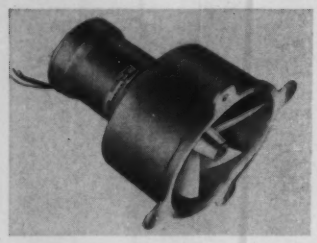
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Variable-Speed Blower

holds mass flow constant as altitude increases

Variable-speed blower is designed for use in systems where a constant volume of air flow is required at varying altitudes. At sea level the speed of the fan is approximately one-third of motor speed. As density of air decreases, reducing air resistance to the blades, speed of the fan, which is magnetically coupled to motor,



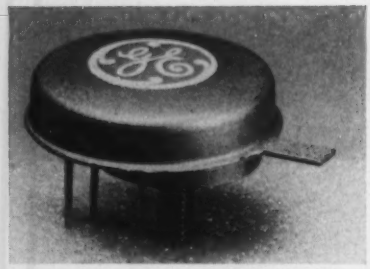
increases, approaching the relatively constant speed of the motor. Thus a higher volume flow is delivered and mass flow is held substantially constant. Minimum mass rate of flow at 60,000 ft is 4.6 lb per min as compared with 7.35 lb per min at sea level. **Eastern Industries Inc.**, 100 Skiff St., Hamden 14, Conn.

Circle 726 on page 19

Silicon Power Transistor

dissipates 85 w at 25 C

New 65-v silicon power transistor, designated 2N451, has applications in dc-to-dc or dc-to-ac converters, as servo-amplifiers in autopilots and engine controls and for driving amplidyne fields, in power supplies as series regulators, and in replacement of mechanical contactors and switches. Capable of dissipating 85 w at 25 C mounting-base temperature, unit has nominal



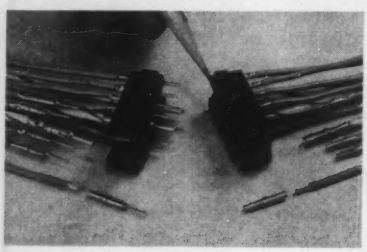
collector saturation resistance of 2 ohms. Input impedance at a collector current of 1 amp is 25 ohms at 25 C. Maximum collector current rating is 5 amp. Transistor is hermetically sealed in an all-welded case designed for mounting on an external heat sink using a single-threaded stud. It meets requirements of MIL-T-19500A. **General Electric Co.**, Semiconductor Products Dept., Electronics Park, Syracuse, N. Y.

Circle 727 on page 19

Solderless Connector

speeds wiring of electronic harnesses

Hyfen multilead connector, which eliminates solder and speeds wiring of electronic harnesses, has two mating units, a plug and a receptacle. Pins and sockets are crimped to wire ends by manual or automatic tools, either before or after harness is in place. Elimination of solder fluxes and dissimilar metals improves resistance



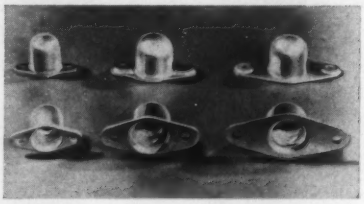
to corrosion. When wires have been tipped with pins or sockets, they are snap-locked in plug and receptacle, which can be mated as a gang connect or disconnect. Pins and sockets can also be pulled out separately to remove individual circuits. **Burndy Corp.**, Norwalk, Conn.

Circle 728 on page 19

Sealed Receptacles

prevent leakage of air, water, and dust

Series of sealed, rigid receptacles have rivet spacings of ¾, 1, and 1⅜ in. Units prevent leakage of air, water, and dust from reaching working parts of equipment. Brass cap is applied by soft soldering to silicon-bronze cast receptacles to



fabricate sealed assembly, which is cadmium plated. Receptacles withstand pressures to 90 psi. **Camloc Fastener Corp.**, 22 Spring Valley Rd., Paramus, N. J.

Circle 729 on page 19

Shaft-Mounted Drive

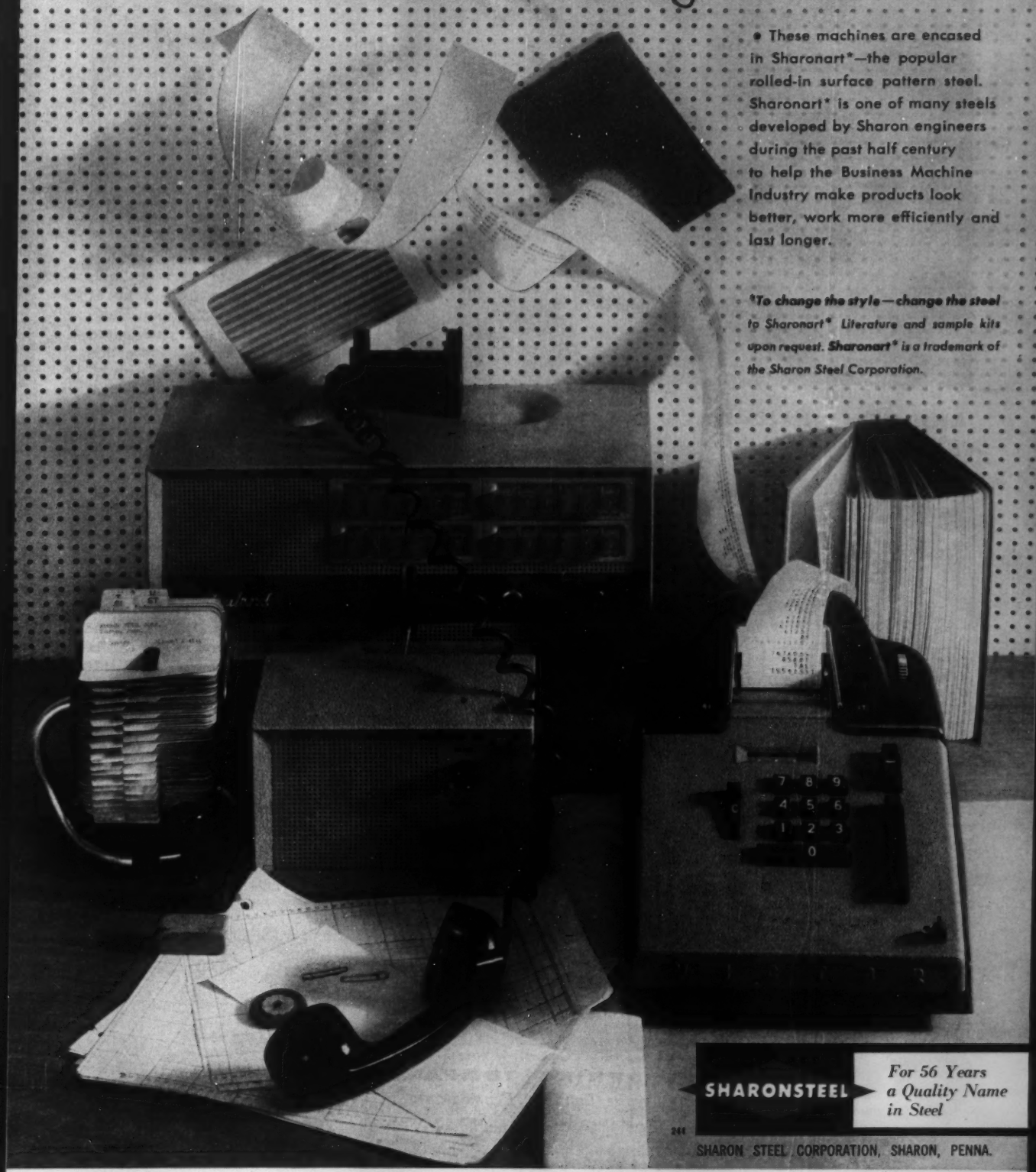
in single or double-reduction types

All-steel 315J shaft-mounted drive incorporates longer center distance between shafts, permitting use of larger sheaves on installations where unit is mounted with input shaft toward driven machine, or on through-shaft applications. Drive is available in a single-reduc-

Circle 502 on page 19→

IN BUSINESS MACHINES, TOO,

Sharonsteel Quality STANDS OUT



• These machines are encased in Sharonart*—the popular rolled-in surface pattern steel. Sharonart* is one of many steels developed by Sharon engineers during the past half century to help the Business Machine Industry make products look better, work more efficiently and last longer.

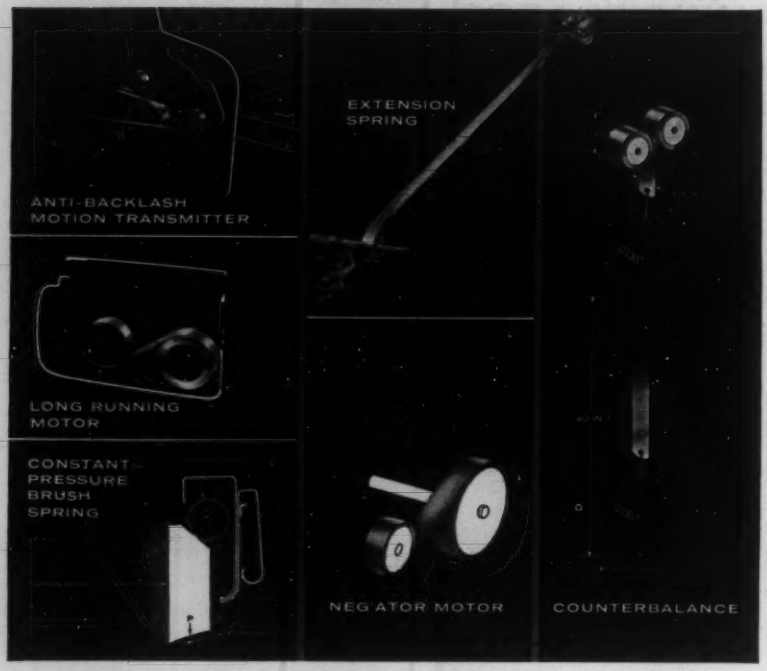
To change the style—change the steel to Sharonart Literature and sample kits upon request. **Sharonart*** is a trademark of the Sharon Steel Corporation.

SHARONSTEEL *For 56 Years a Quality Name in Steel*

244

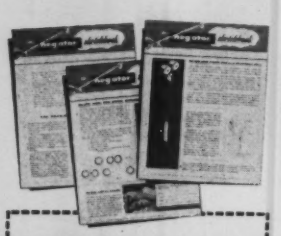
SHARON STEEL CORPORATION, SHARON, PENNA.

CHICAGO, CINCINNATI, CLEVELAND, DAYTON, DETROIT, GRAND RAPIDS, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, NEW YORK, PHILADELPHIA, ROCHESTER, SAN FRANCISCO, SHARON, SEATTLE, MONTREAL, TORONTO

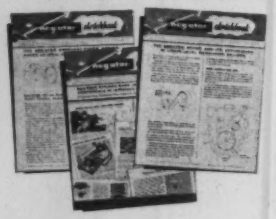


ARE YOU UP-TO-DATE ON THE NEG'ATOR®

The First Practical Constant-Force Spring



The NEG'ATOR Sketchbook



Things are happening fast to the NEG'ATOR Spring.

Its use in instrumentation is growing by leaps and bounds. Still another major camera manufacturer has incorporated a NEG'ATOR motor as the drive unit in a new model. New application stories become available regularly. Many of the predictions made for the NEG'ATOR (by design engineers like yourself) are being realized.

To keep you up-to-date at all times, we are now publishing the NEG'ATOR Sketchbook shown at left. By means of regular issues, we intend to make available to you all types of NEG'ATOR information—new data, new developments, functions, applications, and ideas.

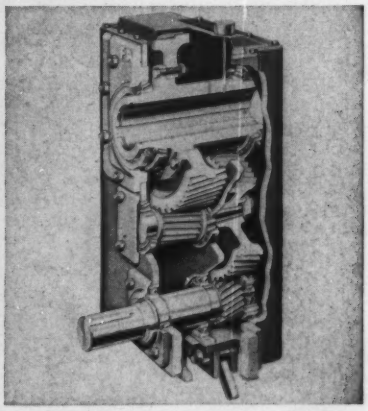
If you will write us, we will be happy to send you all past issues of this publication and add your name to our list for future issues. Contact us today. Ask for the Sketchbook.

HUNTER SPRING COMPANY

3 Spring Avenue, Lansdale, Pennsylvania

SPRINGS • STAMPINGS • TEST APPARATUS

New Parts



tion ratio of 5:1 and two double-reduction ratios of 14:1 or 25:1. Unit ratings range from 2 hp at 5 rpm to 50 hp at 359 rpm. Maximum torque rating at low speed shaft is 31,000 lb-in. Inspection covers on housing provide easy inspection of bearings and helical gears. **Falk Corp.**, Dept. 255, 3001 W. Canal St., Milwaukee 1, Wis.

Circle 730 on page 19

Vinyl Adhesive

bonds vinyl sheets to other materials

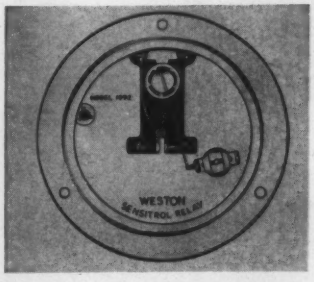
Epocast 126 solventless vinyl adhesive bonds vinyl films and sheets to steel, aluminum, masonite, wood, and other surfaces. Both rigid and most semirigid vinyl sheets can be used. **Furane Plastics Inc.**, 4516 Brazil St., Los Angeles 39, Calif.

Circle 731 on page 19

All-Purpose Relay

sensitive unit is fully adjustable

Fully adjustable sensitive relay provides an almost infinite number of accurately repeatable settings through the turning of one adjusting screw. Unit, which con-



Circle 503 on page 19

Bring on the SHOCKS and EXTREME VIBRATION

IMPERIAL FLEX® FITTINGS

are cushioned to end tube fitting failures!

Imperial Flex fittings thrive on vibration, mechanical shock and minor tube movement. Eliminate a common cause of fitting failure . . . and the need for costly flexible hose lines in many cases. In fact, if properly connected, Flex fittings will never fail under extreme vibration.

Speed installation too — Simply slip nut and sleeve over tubing. Insert tubing into body and tighten nut. That's all! Make pressure-tight joints on all seamed and seamless tubing, including scored tubing or tubing with surface defects. Can be disconnected and reconnected repeatedly without danger of leakage! Even slight misalignment will not cause leakage.

Built to take punishment — Proved superiority on severe applications is a matter of record. Forged bodies on elbows and tees are tough, rugged. Sleeve withstands gasoline and oil . . . flexes perfectly in sub-zero to 250°F temperatures.

Why Flex fittings can't fail

Like resilient mountings for automobile engines, Flex sleeve permits tube to flex back and forth through angle shown. Tubing can't wear because metal-to-metal contact is snubbed. Flex fittings are available for ⅛ to ⅞" O.D. tubing.

Trucks, tractors, heavy power equipment, earthmovers all thrive on Flex fitting vibration-proof protection. Make a test application on your product NOW.

Write for Catalog No. 344.

IMPERIAL

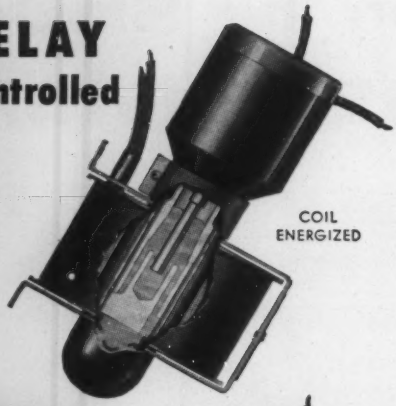
THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 31, Ill.—Dept. MD107
In Canada: 334 Lauder Ave., Toronto, Ontario

Emblem of Quality

SEE YOUR IMPERIAL DISTRIBUTOR: for fittings and tools for copper, steel, stainless steel, aluminum and plastic tubing. He offers Industry's Most Complete Line.

The **TIMER RELAY**
that handles all controlled timing problems . . .

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.

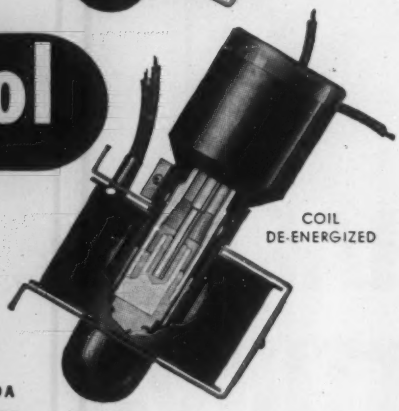


Durakool
STEEL MERCURY TIMERS

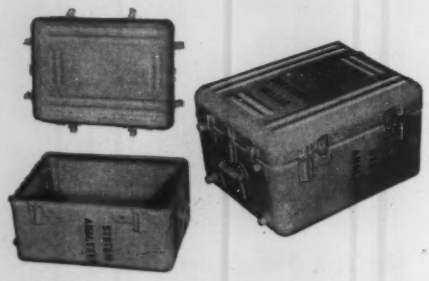
★ No false contacts
★ Non sticking
★ Practically "fail safe"
★ Low cost timer

See telephone directory for local distributor, or write.

DURAKOOL, INC.
ELKHART, INDIANA, U. S. A.
700 WESTON RD., TORONTO 9, CANADA



Circle 505 on page 19



MIL-Spec
military cases, transit cases, combination cases

NO TOOLING COSTS!
using Zero standard deep-drawn aluminum boxes

Choose from more than 1400 standard sizes and save tooling cost. All can be trimmed and modified to your specification by secondary operations...brackets and fasteners installed, holes and louvers punched, welding, painting, etc. Choose from rectangular, round, square boxes and covers. Custom deep drawn parts at nominal cost using exclusive ZERO-method tooling—send your print or contact your local ZERO representative for a quotation.

Write for complete new ZERO catalog

ZERO MANUFACTURING COMPANY
1121 CHESTNUT, BURBANK, CALIFORNIA

Circle 506 on page 19

New Parts

tains a built-in reset mechanism, can be set to close at any dc value from 5 to 50 mu amp or 10 to 100 mv, and handles 100 ma at 120 v ac without chatter. The all-purpose relay has many applications, including use in alarm or control devices, and in breadboard circuits. **Weston Electrical Instrument Corp.**, Div., Daystrom Inc., 614 Frelinghuysen Ave., Newark 5, N. J.

Circle 732 on page 19

Packaged Timer

for ac-operated equipment

Chronistat timer package includes a Chronistor electrochemical elapsed-time indicator, and rectifier-resistor network for direct operation from 115 v ac. Box size

is 2¼ x 1¼ x 1⅝ in. It permits direct installation in ac-operated equipment, such as television sets, electronic instruments, motors, and refrigerators, where elapsed-time measurement is required. Unit can also be used for measurement of diamond needle wear time on phonographs. **Bergen Laboratories**, 247 Crooks Ave., Clifton, N. J.

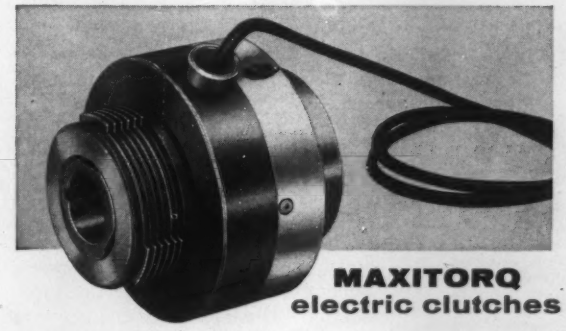
Circle 733 on page 19

Swivel Joint

for steam and hot-gas applications

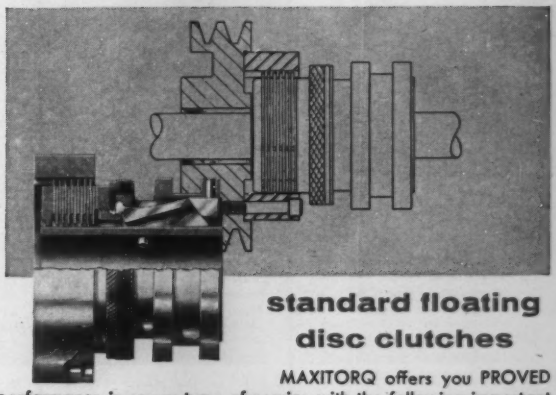
Design of the Discpak permits packing units to be replaced without removing joint from line. Outer housing of joint is cut apart at packing chamber and both ends are flanged at the cut, permitting joint to be parted at packing chamber where disc-type packing seal is located. Designed for steam and hot-gas service, unit has

if your design calls for CLUTCHES



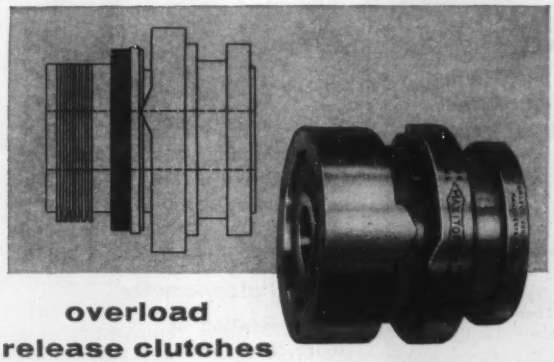
MAXITORQ electric clutches

PROVED design, Floating Disc action is fast and positive, with no heating or drag in neutral. Compact, simple, with few moving parts. For WET or DRY operation: Electrical operating unit DOES NOT REVOLVE; no brushes or slip rings. Use easily replaced standard Disc-Pac. Requires no adjustment. Wide range of standard sizes, single and double types. All sizes rated 80 watts, operate on 110 V, A.C., rectified to 90 V, D.C. Other voltages on special order.



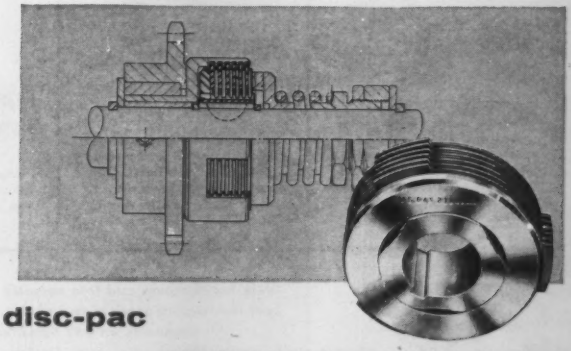
standard floating disc clutches

MAXITORQ offers you PROVED performance in every type of service with the following important advantages: compact design with few and sturdy parts . . . floating neutral with no heating or drag . . . positive engagement or release with light pressure . . . manual assembly and adjustment . . . full power transmission . . . full range of sizes and types . . . supplied as complete, easily installed units.



overload release clutches

One of the simplest and most efficient methods of providing a DEPENDABLE and easily adjusted overload release on machines requiring this safety feature in addition to a clutch. Incorporate all the advantages of MAXITORQ Floating Disc design plus automatic and complete release upon overload. Proved in service. Available in a wide range of sizes.



disc-pac

The "heart" of the SERVICE-PROVED Maxitorq Floating Disc Clutch in a compact, assembled unit for those who wish to design and build their own clutch mechanisms. Supplied as complete units ready for use in 8 diameters 2" to 8", up to 800 ft. lbs. capacity. Also useful as a multiple disc brake or torque limiting device.

Write for complete data and specifications on any or all of the above. If you have a problem involving clutch applications, consult us. A letter or phone call will receive prompt attention. Dept. MD-10.

THE CARLYLE JOHNSON MACHINE COMPANY, MANCHESTER, CONN.

Circle 507 on page 19

PALNUT® LOCK NUTS and FASTENERS

REDUCE — PARTS — OPERATIONS — COSTS

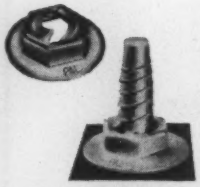
Spring-tempered steel PALNUT Lock Nuts and Fasteners cost less than other lock nuts and locking devices—less than plain nuts, in most cases. A single PALNUT replaces two, three, even four fastening parts according to application and type used, thus fewer parts to buy, stock and assemble. Simplified, high speed assembly is gained with PALNUT magnetic sockets, shanks and applicators which pick up, start and tighten in one operation. Self-locking spring grip keeps parts tight under vibration. Many types and sizes offer savings for products in every field.

REGULAR TYPE

Self-locking hex nuts securely fasten wide range of light assemblies. Require only 3 screw threads. Save weight. Also used on top of ordinary nut for vibration-proof fastening of assemblies.

WASHER TYPE

One-piece lock nut and flat washer replaces ordinary nut, lockwasher and flat washer. Many variations for mechanical and electrical assemblies. Available with bonded-in plastisol sealer.

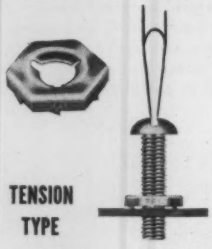


SELF-THREADERS

Form deep, clean threads on unthreaded studs, rivets and rods while tightening. Save threading costs. Provide strong, vibration-proof assemblies. Fast assembly with standard tools. Remove and re-use on same studs.

ACORN TYPE

Pleasing dome shape covers rough screw ends, dresses up products, keeps parts tight. Also semi-acorn type with prevailing torque anywhere on threads. Very low cost.



TENSION TYPE

Simplifies adjusting screw assemblies. Nut is tightened once, never touched again. Use only screwdriver to adjust screw. Positive grip.

PUSHNUTS® for unthreaded studs, rods and rivets.

Simply push on, they lock with powerful grip. Save threading, notching, cotter pins.

WING TYPE

Lock securely when finger tightened, stay tight in service, easily removed when finger released. Cost less than ordinary wing nuts.

Write for literature and free samples of any type PALNUT Lock Nut, stating application and size. Consult our fastening engineers on any assembly problem.

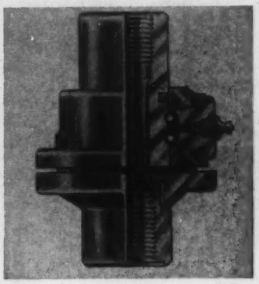
THE PALNUT COMPANY
75 Glen Road, Mountainside, N. J.
Subsidiary of United-Carr Fastener Corp.
Canada: P. L. Robertson Mfg. Co., Inc., Milton, Ont.

PALNUT® LOCK NUTS FASTENERS

Quick, secure fastening at low cost

Circle 508 on page 19

New Parts



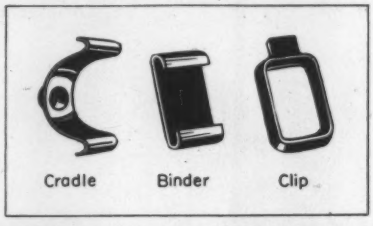
maximum temperature rating of 600 F and maximum pressure rating of 300 psi. It is available in ⅜, ½, ¾ and 1-in. sizes. **Chiksan Co.**, 330 N. Pomona Ave., Brea, Calif.

Circle 734 on page 19

Wire-Harness Supports

for service from −60 to 100 C

Cradleclip wiring system consists of binders and extensible clips for unsupported wiring, and cradles with extensible clips for anchored wiring. Binders and cradles are molded from nylon, and clips are molded neoprene. Units are for service with temperature range of −60 to 100 C. Binders, clips, and cradles are available in sizes for



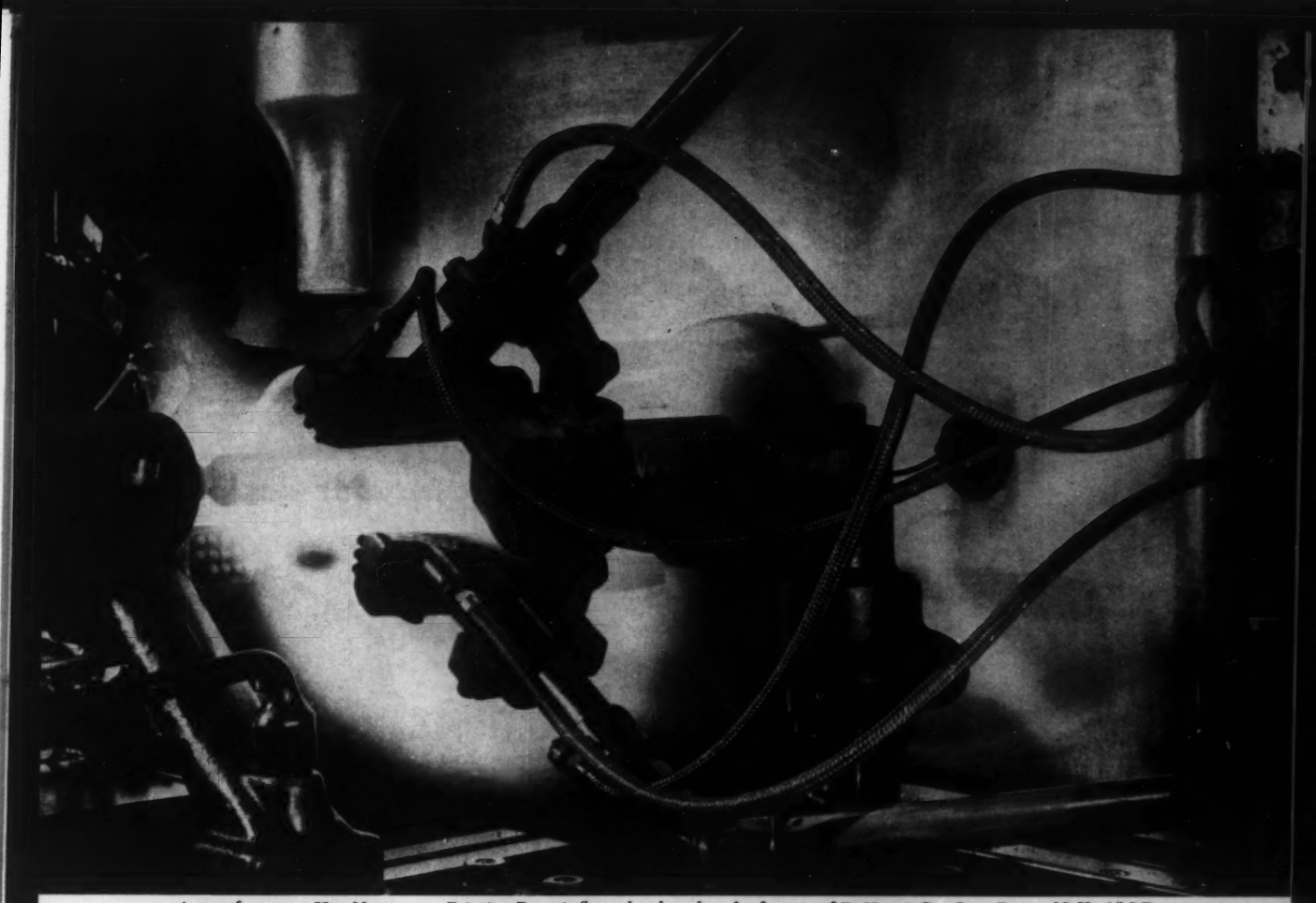
cable groupings having diameters from ¼ to 2¼ in. **Electrovert Inc.**, 489 Fifth Ave., New York 17, N. Y.

Circle 735 on page 19

Vernier Potentiometer

has resolution of more than 0.002 per cent

Rinco 85-A Verni-Pot is a precision voltage divider consisting of two switch-controlled decades of high-accuracy fixed resistors, together with a precision wire-wound potentiometer for continuous interpolation between decade steps. Combination provides linearity better than one part in 10,000 and resolution of more than 0.002 per



A gear for a new Hoe Newspaper Printing Press is flame-hardened at the factory of R. Hoe & Co., Inc., Bronx, N. Y. 1" I.D. seamless bronze American Flexible Metal Hose on the flame hardening machine, shown here, conveys acetylene gas.

Design Problem:

Leakproof gas lines that must flex
. . . withstand heat from outside
. . . corrosive attack from within

Answer:

American Metal Hose

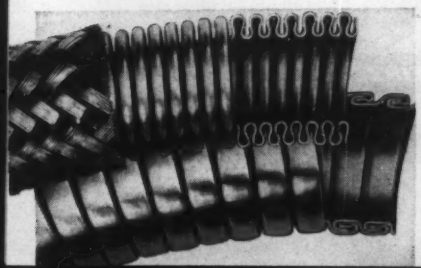
This machine hardens, brazes, and heat processes metal products and parts. The flame heads are adjustable; so the hoses conveying the fuel gas must be flexible. And they must be tough! Corrosive gas attacks them from the inside. High heat is a constant enemy on the outside. Yet they must be leakproof. For safety's sake, they must not fail.

The engineers found the right answer: American Flexible Metal Hose. It delivers more service hours per dollar!

Available in wide range of diameters in bronze, brass, aluminum, steel, monel, stainless steel and other metals—American Flexible Metal Hose is being used by countless manufacturers to convey almost every conceivable gas and liquid . . . to absorb vibration . . . absorb expansion and contraction in lines due to temperature changes . . . facilitate installation, especially in cramped spaces . . . to solve the problem of misalignment.

American furnishes flexible metal and Teflon connectors to your specifications . . . ready for immediate installation. Consult your nearby American Metal Hose representative for engineering help when planning your next job. Just released! New 64-page catalog chock-full of useful information on flexible metal hose and tubing. Write for your free copy: The American Brass Company, American Metal Hose Division, Waterbury 20, Conn.

57174



BASIC TYPES

Seamless corrugated and Strip-wound. Both types available in a wide range of sizes and styles in any workable metal. Furnished with or without end fittings attached.

WHEREVER CONNECTORS MUST MOVE

AMERICAN

FLEXIBLE METAL HOSE AND TUBING

AN ANACONDA® PRODUCT

Circle 509 on page 19

WATCH THE HUMPS IF YOU SCORCH

Back in 1907, speed limit laws were often arbitrarily severe, even if enforcement was apt to be haphazard. The usual limits were 8 miles in town, 15 miles in the country. Those who liked to speed were called "scorchers." To put a damper on the activities of these gay blades, some towns installed sharp ridges or "humps" several inches high across their streets, at regular intervals. If a motorist was foolish enough to run over one of these "humps" at 20 or 30 miles an hour, he was likely to suffer a couple of blown tires or broken springs, as well as considerable discomfort.

Fifty years ago when our founders started in making gears people firmly believed "haste makes waste." Today our standards of "haste" (and "scorching") have changed, at least in degree, but there is still truth in this saying. It particularly applies in making important decisions — such as where to buy your custom gears. A lot of people who have given the matter careful attention come to us for the *best* custom gears obtainable — because they've found out that it pays in the long run. Try us on your next custom gear order, and we think you'll agree with them.

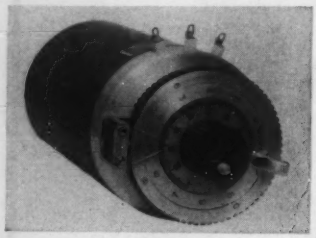
THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
Fifty Years of "Gears—Good Gears Only"

CINTI®

Circle 510 on page 19

New Parts

cent. Control is provided through three coplanor dials mounted on coaxial shafts, enabling unit to be mounted in a single 7/16-in. diam panel hole. Locking device on dial prevents accidental changes in set-



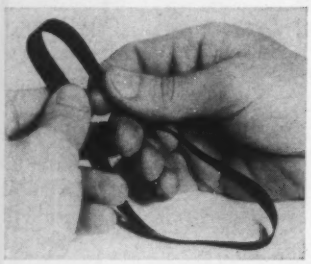
ting. Less than three turns of calibrated dial cover full range of resistance decades. Voltage accuracy is ordinarily independent of ambient temperature. **Research Instrument Corp.**, 7962 S. E. Powell Blvd., Portland 6, Oreg.

Circle 736 on page 19

Transmission Belt

for high-speed transmission

Rusco Ultra-Speed M flexible transmission belt operates at speeds to and above 100,000 rpm over pulleys with diameters as small as 3/8 in. The thin, flat belt is a blend of strong, stretch-resistant synthetic and natural fibers. Developed for high-speed



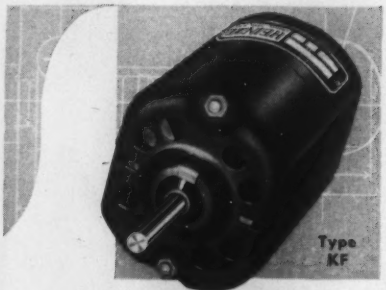
transmission, belt can be used at any spindle speed. **Russell Mfg. Co.**, 466 E. Main St., Middletown, Conn.

Circle 737 on page 19

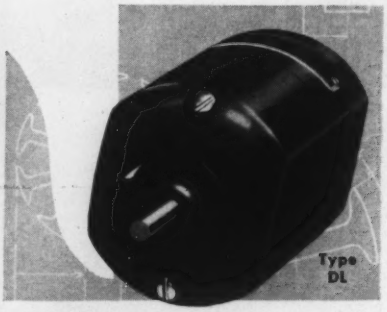
Plug-In Amplifier

is 20-w transistorized unit

Occupying only 50 cu in., 20-w transistorized plug-in amplifier replaces units more than eight times its size. Unit, designed for incorporation into public address systems, has built-in equalization, sig-



put HEINZE in your designs



VERSATILITY... IN HEINZE UNIVERSAL MOTORS

Variable speed . . . high starting torque . . . reversibility . . . high output . . . you get them all in Heinze Universal Motors. Horsepower ratings are from 1/15 hp to 1/50 hp, with load speeds of 5000 to 7500 rpm. Normally designed for 115V AC/DC, CW, CCW or reversing. Other voltages are available. Internal or external brushes may be supplied. Type DL has die cast housing. Broad applications include sewing machines, business machines, movie projectors, electric organs, small hand tools.

You have a wide choice of models from the comprehensive line of Heinze sub-fractional horsepower motors and blowers. Send us your product and specifications. Heinze Engineers will adapt a motor, at no obligation. Or write for catalog.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.

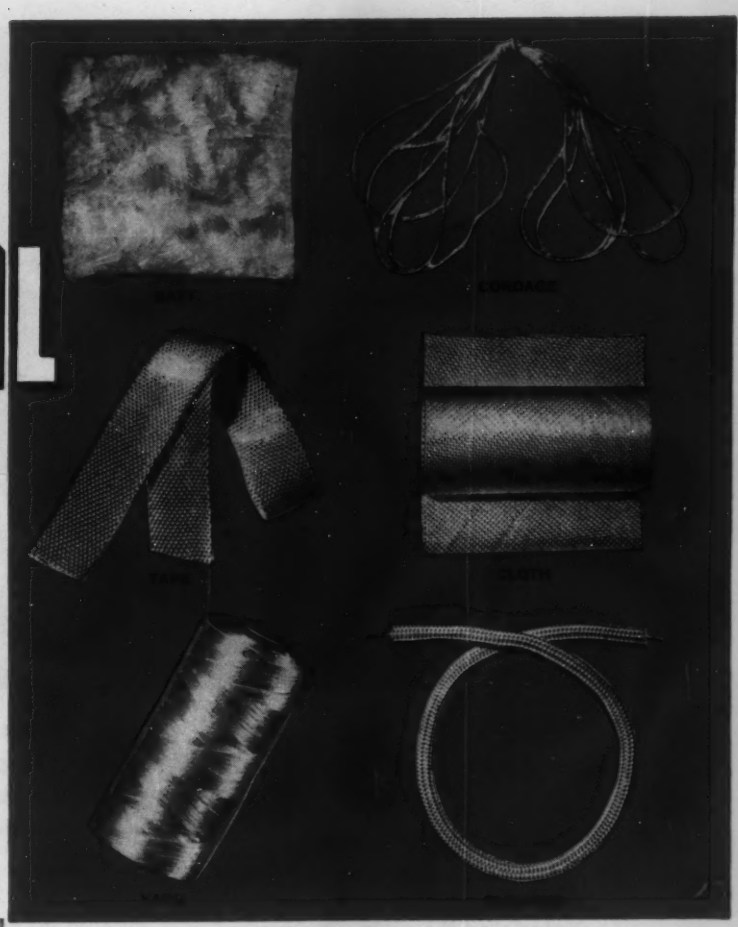
Sub-Fractional Horsepower Motors and Blowers

Circle 511 on page 19

where can you use REFRASIL

2000°-3000° F. High Temperature Insulation

...it may be the special insulation you've been looking for!



REFRASIL PROPERTIES:

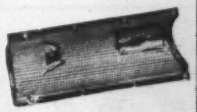
- Chemical resistance of pure silica
- Resists temperatures up to 3000°F. under certain conditions
- Low Thermal conductivity
- Fiber diameter .00020—.00040 in.
- Specific heat .19
- Thickness .14—.15 in.
- Surface density .05 lb./sq. ft.

REFRASIL USES:

- 2000°F. continuous high temp. insulation
- Filtration of corrosive materials
- Removable, insulating blankets
- REFRASIL and plastic laminates
- Thermocouple wire insulation
- Electric muffle furnaces
- Laboratory heating mantles

REFRASIL INSULATING BLANKETS:

"WRAP-AROUND"



"PRE-FORMED"

WHAT IS REFRASIL? REFRASIL is a highly efficient fibrous silica insulation material, extremely light in weight and bulk and made in a variety of physical forms.

REFRASIL has proven its high temperature insulation ability in millions of hours of jet aircraft operation. It is fast becoming an important industrial insulation for critical and extreme temperature applications from −300°F. cold to +3000°F. heat. Despite relatively high initial cost, REFRASIL is economical when restricted to special high temperature uses where ordinary insulation materials fail.

If you need an efficient, lightweight 2000°-3000° insulating material in bulk fiber or any of the physical forms shown, REFRASIL may be your best answer. For your *special* high temperature insulation problems, our research and development engineers are only a phone call away. Call or write for complete engineering information and free samples of REFRASIL, for your own testing.

• FREE NEW CHART!

First of a Series, this new High Temperature Insulation Chart contains helpful information on insulation for temperature ranges from −300° to +3000°F. Write for your free copy today!

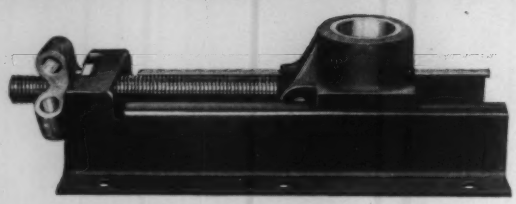
HITCO **H. I. THOMPSON FIBER GLASS CO.**
1733 Cordova Street · Los Angeles 7, California
REpublic 3-9161

HITCO HELPS INDUSTRY BEAT THE HEAT

WRITE OR CALL YOUR NEAREST REFRASIL REPRESENTATIVE • EASTERN: TOM KIMBERLY, 38 Crescent Circle, Cheshire, Conn., BRowning 2-6544 • MIDWEST: BURNIE L. WEDDLE, 3219 W. 29th. St., Indianapolis 22, Ind., WAlnut 5-8685 • SOUTHWEST: MARSHALL MORRIS, 3515 Covert Ave., Ft. Worth, Texas, WAlnut 3-8098 • NORTHWEST: J. L. LARSEN, 5757 Oaklawn Place, Seattle, Wash., MOhawk 9311 • CANADIAN PLANT: THE H. I. THOMPSON CO. OF CANADA LTD., 60 Johnston St., Guelph, Ontario, TAylor 2-6630

For a BALANCED INSTALLATION

fit the Take-Up to the job!



DODGE TYPE A TAKE-UP...BABBITTED

DODGE G AND GM BALL BEARING TAKE-UP

DODGE-TIMKEN TYPE E TAKE-UP

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new methods. Look for his name under "Power Transmission Machinery" in your classified telephone book, or write us.

Choose from America's Complete Line of Stock Models and Sizes

For the latest information on take-ups, call your Dodge Transmissioneer. With a complete line available from stock, he is in a position to recommend impartially the take-up best suited to your conveyor system, and to save you money. Babbitted, Bronzoil, Ball and Roller Bearing types in shaft sizes from 1/2" to 4-15/16". Write us for literature.

DODGE MANUFACTURING CORPORATION
3300 Union Street • Mishawaka, Indiana

LIGHT DUTY

BRONZOIL
1/2" to 1"

NORMAL DUTY

SC and SCM Ball Bearing
3/4" to 2-7/16"

G and GM Ball Bearing
1-15/16" to 2-7/16"

TYPE A Babbitted Bearing
15/16" to 2-7/16"

TYPE B Babbitted Bearing
15/16" to 2-7/16"

TYPE H Babbitted Bearing
1-15/16" to 3-15/16"

HEAVY DUTY

TYPE E Dodge-Timken Bearing
1-3/4" to 3-15/16"

ELEVATOR BOOT Dodge-Timken
1-3/16" to 2-15/16"

ANGLE FRAME Dodge-Timken
1-11/16" to 4-15/16"

DODGE
of Mishawaka, Ind.

Circle 513 on page 19

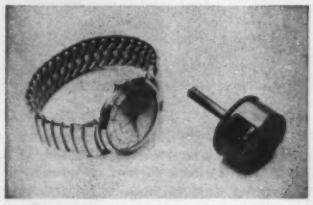
nal-to-noise ratio greater than 30 db, and less than 3 per cent harmonic distortion at low-frequency end. Amplifier includes peak clipping and gain control, and meets military environmental specifications. **Universal Transistor Products Corp.**, 143 E. 49th St., New York 17, N. Y.

Circle 738 on page 19

Vane-Pump Cartridge

miniature unit delivers 1.04 gpm at 1000 psi

Less than 1⅛ in. in diameter, this vane-pump cartridge weighs only 2.5 oz. It can be manifolded effectively with servo valves, miniature piston hydraulic motors, and fractional-power electric motors. Unit delivers 1.04 gpm at 1000 psi and 10,000 rpm, an output of 0.6 hp. Optimum running clearances are automatically main-



tained by vanes and pressure plates that are self-compensating for wear. Hydraulic balance eliminates pressure-induced bearing loads. **Vickers Inc.**, Detroit 32, Mich.

Circle 739 on page 19

Flat Aluminum Wire

in thicknesses from 0.020 to 0.187 in.

Round-edge, flattened aluminum wire has many applications in the electrical industry, such as in primary and secondary transformer windings, current-limiting reactors, welding transformers, and armor for electrical cable. Other applications include ornamental grillwork, utensil components, staples, and zippers. Wire is available in thicknesses from 0.020 to 0.187 in., in widths from 0.063 to 1.000 in. Materials include EC grade, and 1100, 3003, 5052, and 5056 alloys. **Kaiser Aluminum & Chemical Sales Inc.**, 919 N. Michigan Ave., Chicago 11, Ill.

Circle 740 on page 19

Sealed Casters

incorporate synthetic-rubber ring seals

Positively sealed industrial casters are available in rigid and swivel models in practically every size, capacity, and wheel type. Casters employ precision-molded synthetic-

rubber ring seals and a formed-steel, leakproof retainer cup to insure positive grease-retaining protection. Race seals cannot be distorted by excessive lubrication pressures. Wheel bearings are lubricated through hollow axle shaft. **Albion Industries Inc.**, Albion, Mich.

Circle 741 on page 19

Synchronous Motor

small, heavy-duty unit is rated 40 oz-in. at 1 rpm

Only 2½ in. in diam and 1¾ in. deep, this heavy-duty synchronous motor starts instantly with full load at rated torque and operates continuously with maximum temperature rise of only 45 C above ambient. Torque rating is 40 oz-in. at 1 rpm. Models are available with speeds from ½ to 360 rpm through gearing, and 1800 rpm di-

(*Please turn to Page* 198)

DODGE PRODUCTS you should know

FLEXIDYNE
THE DRY FLUID DRIVE
100% efficiency at full load!

TAPER-LOCK
STEEL CONVEYOR PULLEYS
Maximum strength with minimum weight!

ROLLING GRIP
FRICTION CLUTCHES
Positive! Smooth! No toggles!

Write for Bulletins!

- Flexidyne Dry Fluid Drives and Couplings. Bulletin A-640-A.
- Taper-Lock Steel Conveyor Pulleys. Complete data. Bulletin D-56.
- Rolling Grip, Diamond D, Air-Grip Clutches. Bulletin D-56.

DODGE MANUFACTURING CORPORATION
3300 Union Street • Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

Circle 514 on page 19

Designed for Stre[illegible] and Safet[illegible]

STRENGTH AND SAFETY are built-in features of this seat-belt buckle made from Republic Stainless Steel, Type 201. Fabricating operations include: shearing into blanks of .125 thickness, punching, a severe bend of 175° to form the hook.

SAFETY ASSURED by designing the high strength advantage of stainless steel into the simple beak-type buckle. No intricate springs or mechanisms to fail at the wrong moment. Both belt and buckle are rated 1000 pounds in excess of CAA specifications.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

with STAINLESS STEEL

SEAT-BELT MANUFACTURER LICKS CRITICAL PROBLEM WITH REPUBLIC ENDURO, TYPE 201

Here are the facts on a new and cost-cutting use of Republic ENDURO® Stainless Steel, Type 201, by Bunke-Musser Company, Jackson Center, Ohio, manufacturers of safety seat-belts for the automotive industry.

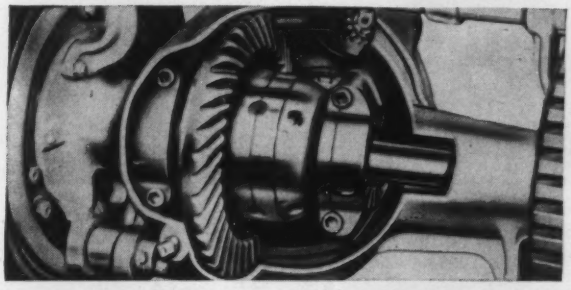
The most critical part of the entire assembly is the buckle. It must conform to Associated Seat Belt Manufacturers' specifications. These require that the buckles be subjected to a test pull of 1500 lbs., then reduced to 125 lbs. At this point, the pelican hook of the buckle must be capable of release at 45 lbs. pressure.

Prior to adoption of Type 201, another grade of stainless had been used. However, the slightly softer surface of this type resulted in a galling action at the fulcrum of the buckle when the release pressure was applied.

Bunke-Musser also experimented with carbon steel. But this required use of heavier gage, chrome plating and polishing, with the end result being much more expensive than stainless steel.

Now the company has standardized on Republic, Type 201, with excellent results. The buckles meet and exceed test specifications. The galling action has been eliminated. Tensile strength increased 200 lbs.

Types 201 and 202 are relatively new members of Republic's family of stainless steels. Republic Specialists will be happy to work with you in designing these new grades into your product. The 200 Series offers high strength, corrosion-resistance and easy forming on your present equipment. And they are readily available. Mail the coupon for more information, or if you would like a Republic Specialist to call at your plant. There's no obligation.



THERE'S NO SACRIFICE OF STRENGTH OR SAFETY in this drive axle designed from Republic Alloy Steel. In these fine steels you will find the highest strength values—plus an exceptionally high strength-to-weight ratio that permits transmission of hundreds of horsepower through tough, strong axles, shafts and gears, free from excess weight. Republic Alloy Steels are essential in designing smaller sections to carry heavier loads safely—essential in extending equipment life and reducing maintenance and replacement costs. Send coupon for data.

A BUILT-IN SAFETY FACTOR is one reason why Republic Nylok Nuts are being used in thousands of critical applications to resist shock, vibration and cyclic loading. The answer is in the nylon plug in one face of the nut which forces threads on other side tight against bolt or stud. Above, Nylok Nuts provide a powerful clamp action and keep vital steering tie-rod assembly securely in adjustment. Nylok Nuts can be removed for maintenance of parts, then re-used with no loss in holding power. And because either end is up they are ideal for automatic feeding and power wrenching. Send coupon for more facts.

STEEL

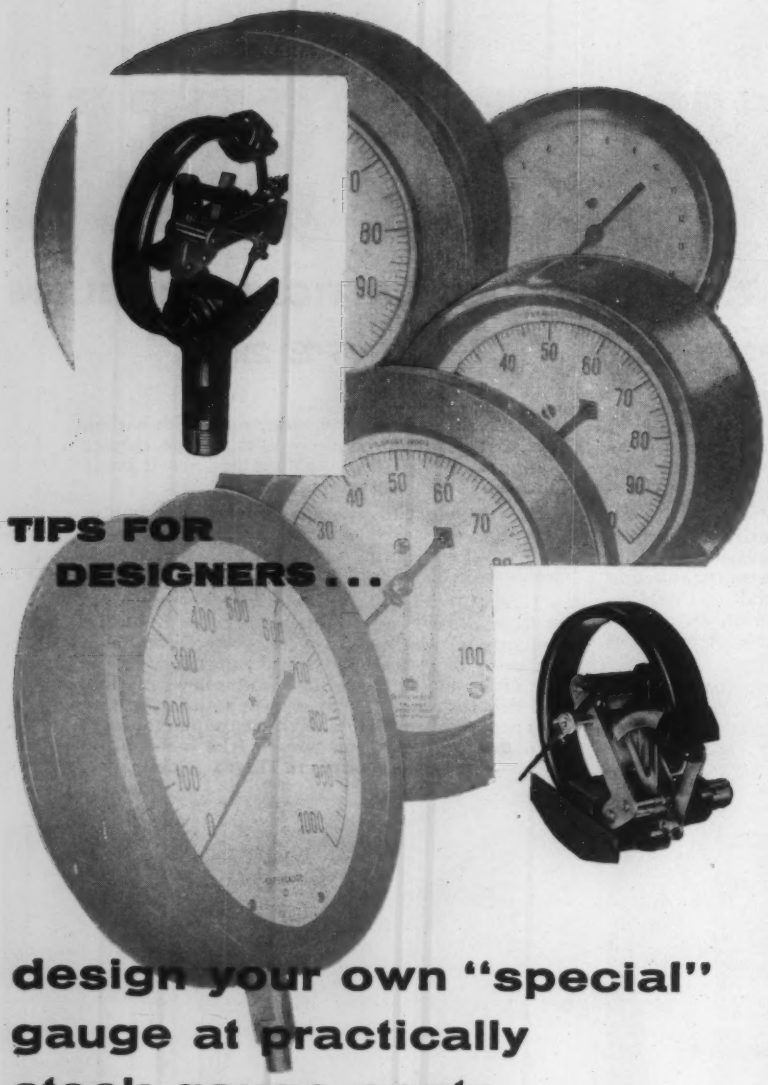
and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-2865 R
3130 East 45th Street • Cleveland 27, Ohio

☐ Please have a Republic Specialist call.
Send more information on:
☐ 200 Series Stainless Steel ☐ Alloy Steels ☐ Nylok Nuts

Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____

Circle 515 on page 19



TIPS FOR DESIGNERS . . .

design your own "special" gauge at practically stock-gauge costs

Before you specify an expensive special gauge, check your requirements with USG. Available to you are 50,000 different standard gauges. With slight modification, many of these will meet special design problems.

USG saves manufacturers thousands of dollars annually by making possible "special" gauge designs from standard components. For help with your gauge problems call or write the factory today.

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MORE THAN 50,000 TYPES OF GAUGES • SUPERGAUGES • SOLID FRONT GAUGES • RECEIVER GAUGES • TEST GAUGES • RECORDERS • CONTROLLERS • TRANSMITTERS • PSYCHROMETERS • AVIATION INSTRUMENTS

New Parts

(*Continued from Page* 195)

rect drive. Operative in any position, motor can be stalled indefinitely without damage to coil. Drive shaft of ¼ in., in any length, is standard. Timing accuracy is

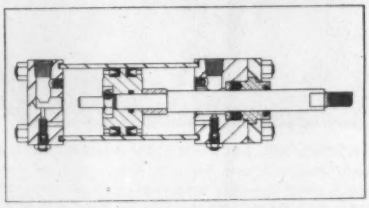
maintained through temperature range from −40 to 250 F. **Hurst Tool & Mfg. Co.**, Princeton, Ind.

Circle 742 on page 19

Air Cylinder

operates with 200-psi air or oil

Square air cylinder has U-cup piston packing, Chevron rod packing, and rod scraper of homogeneous synthetic rubber. Piston is positively locked on rod with nut and grub screw. Shell is cold-drawn seamless-steel tubing, honed to 15-20 mu in., cadmium or hard-chrome plated. Operating pressure of cyl-



inder is 200 psi air or oil. It is available with 1½ through 10-in. bore in a complete range of mounting styles. **Lynair Inc.**, 3100 Michigan Ave., Jackson, Mich.

Circle 743 on page 19

Light-Beam Projector

miniature unit is for close-proximity use

Model 6375 light-beam projector, which can be mounted readily in a single 11/16-in. diam hole, is designed for close-proximity use with miniature photoelectric cells. It operates on nominal 0.15-amp input of 6.3 v, ac or dc. Access to

Circle 516 on page 19

ALNICO MAGNETS cover a wide variety of applications: for aircraft electric motors, compass needles, denture inserts, hearing aids, toy train magnets and many instrument applications. Finishing costs for them all are kept down by the Accumet precision investment casting process at Crucible.

accurate dimensions *of these Crucible investment castings* lower finishing costs

Because the castings in the picture are Alnico magnets, their finishing usually calls for costly grinding operations. That's because Alnico materials are hard and brittle. These castings, however, need virtually no finishing at all. The reason is to be found in the type of casting: Crucible Accumet® precision investment casting.

Crucible uses hot molds with special inner linings for producing Accumet precision investment castings which give two advantages: (1) they turn out castings to close tolerances, and (2) they produce surfaces that are exceptionally fine. These two advantages virtually eliminate all finishing operations. Crucible precision investment castings are available in a complete range of stainless, tool, and alloy steels, as well as Alnico permanent magnets.

For detailed information, write for booklet on "Crucible Accumet Investment Castings". Or you can find out exactly what type of castings you need by calling your Crucible representative.

Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.

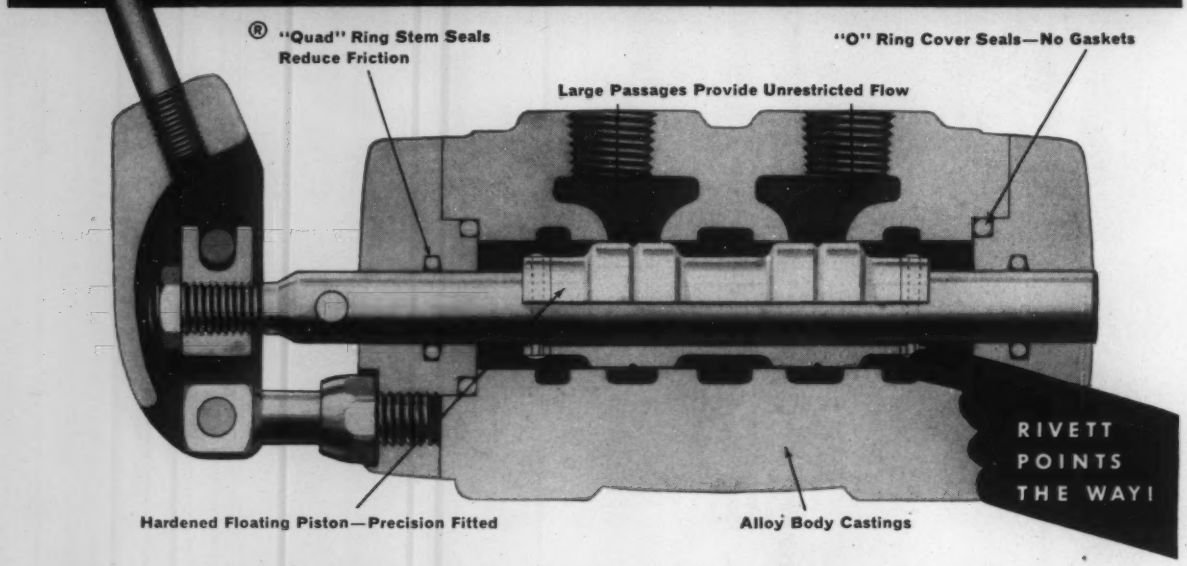
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

Circle 517 on page 19

No Stick! No Bind!


® "Quad" Ring Stem Seals Reduce Friction
"O" Ring Cover Seals—No Gaskets
Large Passages Provide Unrestricted Flow
RIVETT POINTS THE WAY!
Hardened Floating Piston—Precision Fitted
Alloy Body Castings

-with Floating Piston!

Valve Stem is Independent of Valve Bore in Rivett Hydraulic Pipe Mounted Valves

Other Fine Features Benefiting Your Circuit Design and Operation

- "Quad" Ring Stem Seals Reduce Friction
- Large Passages Provide Smooth, Full Capacity Flow
- Simple Design Assures Leakproof Operation
- Opens And Closes Smoothly, Positively
- Operates Multi-Million Cycles At 1500 P. S. I.

1607 VALVE SELECTIONS!

Types: Hand, foot, cam, solenoid, pilot, oil pressure, air pressure, flow control, check, deceleration, relief, unloading, sequence, counterbalance.

Sizes: ¼", ⅜", ½", ¾", 1", 1¼", 1½".

Actions: Standard, spring-return, spring-centered, ball detent.

Mountings: Pipe mounted; panel mounted.

P.S.I.: 1500 P.S.I.; 3000 P.S.I. oil service.

Piston designs for any circuit.

RIVETT, INCORPORATED • Dept. MD-10
Brighton 35, Boston, Mass.
Member National Fluid Power Association

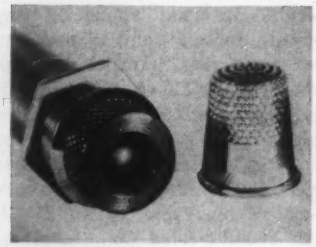
THE BETTER YOU KNOW HYDRAULICS THE BETTER YOU LIKE

Get Catalog No. 204 to aid your circuit design. Complete drawings, specifications, cut-away views, tables, diagrams!

® "QUAD RING" is the registered trademark of the Minnesota Rubber and Gasket Company.

RIVETT
"100"
HYDRAULIC VALVES

Circle 518 on page 19



miniature bayonet-base lamp is accomplished through removal of knurled protective ring. **Autron Engineering Inc.,** 1254 W. Sixth St., Los Angeles 17, Calif.

Circle 744 on page 19

Phenolic Molding Compound

withstands temperatures to 400 F

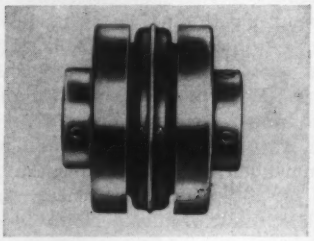
Applications for No. 12929 general-purpose black molding material include precision-made camera parts, piano keys, and rugged, glossy-finish appliance parts. Suitable for use in either cold-powder or preheated pill molding, compound exhibits low shrinkage and minimum thermal expansion. It offers excellent dimensional stability and withstands temperatures to 400 F. **General Electric Co.,** Chemical Materials Dept., One Plastics Ave., Pittsfield, Mass.

Circle 745 on page 19

Flexible Coupling

has rubber-toothed sleeve

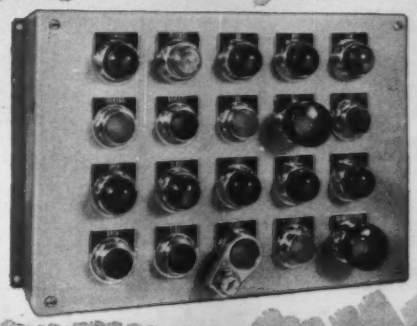
Sure-Flex flexible cushion coupling, for use where mechanical power is to be transmitted, has three basic parts: Two hub flanges and a two-piece rubber sleeve. Internal and external teeth of flexible sleeve mate with flange-hub teeth and lock tight under torque load without clamps or screws. High torsional flexibility of approximately 15 deg at peak torque provides smooth power transmission. Unit



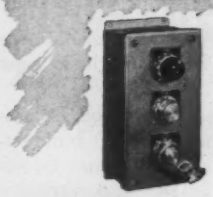
INTRODUCING THE New

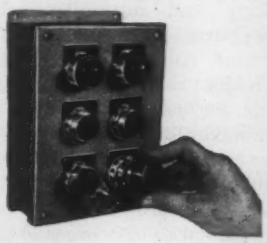
FURNAS ELECTRIC

Oil Tight PUSH BUTTONS



DESIGNED FOR EVERY APPLICATION





Now for the first time, because of standardization and interchangeability, more combinations of Oil Tight push buttons are available with fewer parts. As a result, Furnas Electric design and research again lead the field, this time with the finest oil tight push buttons available.

When you specify Furnas Electric, you get one standard contact block. No rights or lefts—no special units for horizontal or vertical mounting.

Accessories (key lock, mushroom head or lever) are mounted directly on all standard operators. Operators need not be modified or removed from panels.

For full information on oil tight or general purpose push buttons, selector switches or pilot lights, write today for Catalog 5606. Furnas Electric Company, 1045 McKee Street, Batavia, Illinois.

A16

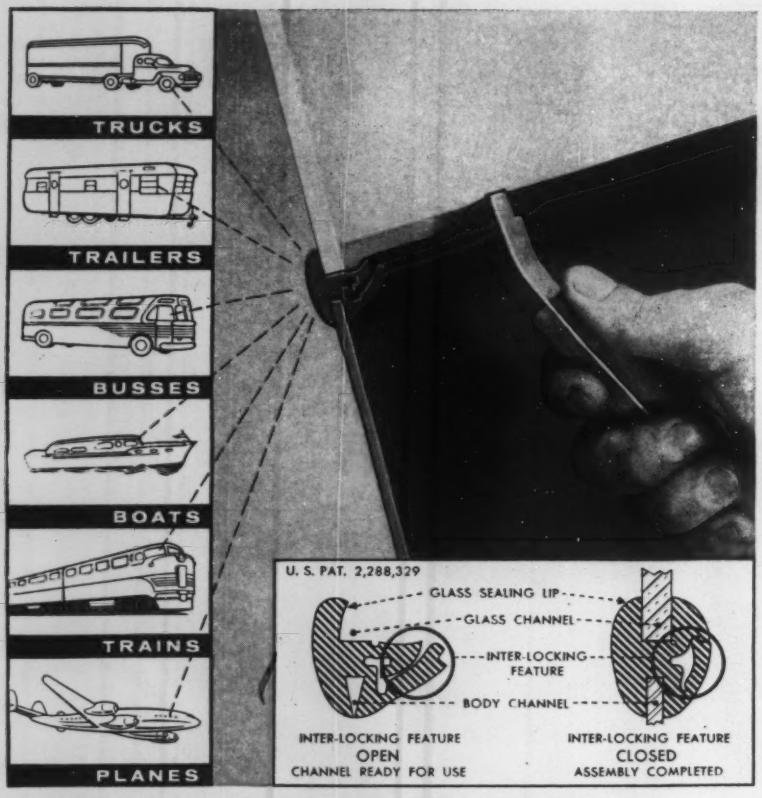
FURNAS

FURNAS ELECTRIC COMPANY

BATAVIA, ILLINOIS

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

Circle 519 on page 19



Self-Locking Rubber Channel for Mounting Glass in Body Panels

Its *one-piece* design locks and seals in one operation. No extra locking-strip needed. It's the faster, simpler method for mounting glass in any type body panel—truck, trailer, bus, boat, train, plane, etc.

Extruded with inter-locking feature at direct right angle to body, the Continental Channel permits unhampered insertion of glass. Locking tongue is pressed into its matching groove which forces the lips against *both* the glass and body panel—a more positive seal with exceptional push-out pressure.

Compounded for maximum weather resistance and extra long life. Close durometer tolerances are held for uniformly tight seal against moisture and surest possible locking. These rubber channels can be positioned first on *either* glass or body panel. All details are shown in illustrated brochure gladly sent on request.

Ordered and re-ordered by the most prominent body builders, this Self-Locking Channel is another example of the creative thinking and ingenuity behind rubber parts by Continental. When you need rubber parts to do a specific job, call a rubber specialist *during the planning stage.* This often makes for economy as well as better end results. Call Continental —rubber specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

New Parts

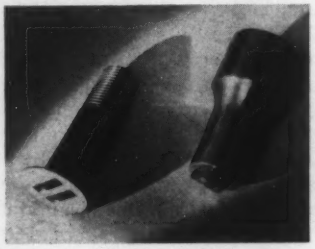
tolerates internal abuse or high resisting forces, angular misalignment to 1 deg, parallel misalignment from 1/32 to 1/16 in., depending on shaft size, and free end-float to ⅛ in., depending on size. Coupling is available in six sizes for 3 to 80-hp motors. Shaft bores are available from ⅝ to 2¼ in. **T. B. Wood's Sons Co.,** Chambersburg, Pa.

Circle 746 on page 19

Flush-Head Bolt

has new recess for greater torsion strength

High-strength, flush-head bolt, designated Multitork, is a cold-head recess fastener which provides greater torsion strength, up to 50 per cent increased fatigue life, and reduced breakage during installation and maintenance. Recess con-



sists of two uniformly radiused slots separated by a portion of bolt head. Multitork can be headed in tool steels, Vasco-jet, and super alloys. It is offered in bolt sizes of ¼ through ⅝ in. shank diam. **Briles Mfg. Co.,** Kansas & E. Grand Sts., El Segundo, Calif.

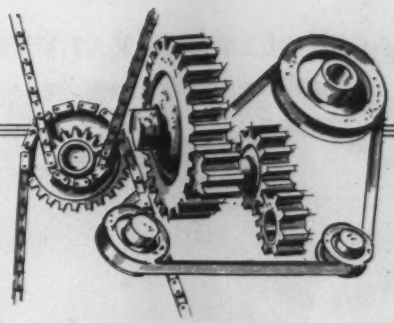
Circle 747 on page 19

Hydraulic Control Valve

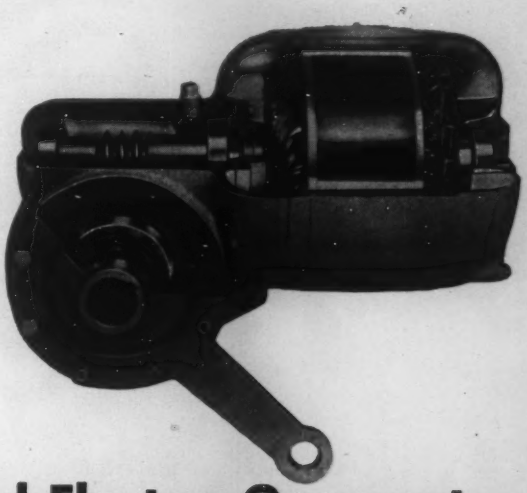
is rated at 20 gpm capacity

VDP2 hydraulic directional control valve is for earthmoving, material handling, agricultural, and other mobile equipment. It provides excellent metering characteristics in raising, positioning, rotating, holding, or lowering operations, and has exceptionally low pressure drop. Five models are available with one to six spools. Valve is rated at 20 gpm capacity, and recommended operating pressure is up to 200 psi. Open-center, parallel-circuit design permits inde-

you can eliminate many of the design and maintenance problems of these ——————



with latest lighter weight shaft mounted gearmotors like this ——————



new shaft mounted Electra-Gearmotors put the power closer to point of use

...and simplify your design

In a very basic way, these exceptionally light weight right-angle gearmotors may solve many mounting problems. They permit you to place the power source closer to the point of use. They thus definitely eliminate many of the complex and cumbersome mountings and power transmission systems often necessary with motors of ordinary mount. The results are simplicity, efficiency, safety. Machines are more compact. Maintenance requirements are lowered. The motors are available in ¼ through 5 H.P. in any speed you require.

As a pioneer in the development of shaft mounted gearmotors and mounting techniques, Electra Motors, Inc. is exceptionally well qualified to help simplify your problem.

FOR CATALOG 56 containing engineering data, call your nearest Electra Motors man or circle 521—— on reader service card. *Need specially designed motors?* Write Applications Engineering Division for immediate service on any problem, any size or quantity.

1ST TO GO ALL THE WAY WITH ALUMINUM•

**Housings of heat treated alloy of aluminum* help simplify design even further by giving you:

- **Up to 60% lighter weight** to increase the number of practical applications for shaft mounting.
- **Faster dissipation of destructive heat**—4.7 times faster than cast iron or steel. Gives a more dependable, longer lived motor.
- **Increases tensile strength 23%** and provides greater shock resistance than ordinary housings.
- **Resists corrosion better,** reducing maintenance and giving greater variety of applications.

ELECTRA MOTORS, INC.

1110 No. Lemon St., Anaheim, Calif. •
Phone KEystone 5-6061

First in Aluminum... Foremost in Quality

Specify **NUMATICS VALVES**
...there are no "equivalents"

MANIFOLDS

DSA34 valves mount interchangeably with all other SA Series air valves on Numatics air and conduit manifolds.

LINE VALVES

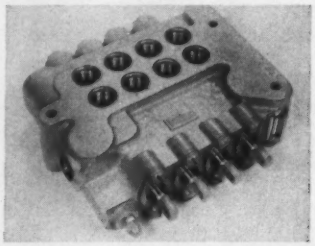
Numatics makes a complete line of foot-mounted, line-mounted 2- and 3-way valves, too. Ask for Bulletin #4000.

Today's control demands, particularly in automation applications, require a host of unusual air circuits . . . emergency stop inching circuits, dumping both ends of cylinder to exhaust, pressurizing both cylinder ports, to mention a few. The valves for jobs like these? Numatics spring-centered DSA34 valves . . . the valve series that gives you split-second response, takes pressure surges without sticking or fluttering. Numatics DSA34 valves are offered, what's more, in a wider variety of sizes and actions than any similar valves now on the market. Want more details? Send for Numatics new Bulletin #558A on unusual circuits using 3-position valves.

NUMATICS, Inc.

HIGHLAND, MICHIGAN Dept. MD

New Parts



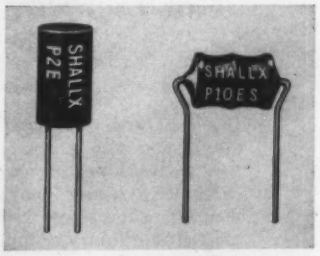
pendent or simultaneous operation of two or more cylinders or hydraulic motors at one time. Spool types include single-acting, double-acting, and float. **Parker Appliance Co.,** Industrial Hydraulics Div., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle 748 on page 19

Miniature Resistors

are wire-wound units for printed circuits

Two miniature resistors are fixed, noninductive, wire-wound types sealed in epoxy resin and suitable for operation in temperatures to 125 C. Distance between leads is closely controlled for manual or automatic insertion in printed circuit boards. P-2 resistor is available in resistances to 200,000 ohms with tolerances to 0.1 per cent.



P-10S resistor is furnished with resistances to 1 megohm with tolerances to 0.1 per cent. Both resistors meet MIL-R-9444. **Shallcross Mfg. Co.,** Collingdale, Pa.

Circle 749 on page 19

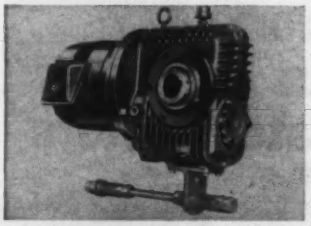
Hollow-Shaft Gearmotors

provide high output torque settings

By combining double-enveloping worm gearing with a helical primary stage, hollow-shaft double-reduction gearmotors provide high output-torque ratings, and compact housings. Large taper roller

Circle 522 on page 19

bearings are used on all shafts. Shafts can be driven in any position with a floating power unit. Simple torque arm ties gearmotor down. Units are available for 1 to 15-hp standard NEMA D-flange motors. Output speeds range from 7.3 to 525 rpm in 27 increments with 1750-rpm motors. One-eighth of gear teeth are always in



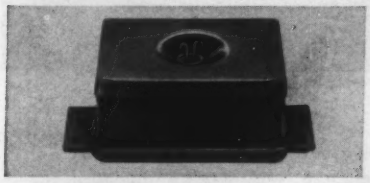
mesh, so that resulting high-area contact between worm and gear teeth spreads unit loads over a large area and provides high resistance to shock loads. **Michigan Tool Co.**, Cone-Drive Gears Div., 7171 E. McNichols Rd., Detroit 12, Mich.

Circle 750 on page 19

Watertight Buzzers

in contact and contactless types

Watertight buzzers operate under severe exposure to elements. Normally available as totally enclosed units buzzers are also hermetically sealed when required by service conditions. Units are available in a contact-type mechanism for voltages from 6 to 48 v ac or dc, and



in a contactless model for ac service at 8 to 48 v. Pitch is nonadjustable. **Auth Electric Co. Inc.**, 34-20 Forty-Fifth St., Long Island City 1, N. Y.

Circle 751 on page 19

Electrical Stop Clock

is accurate within 0.01 sec

Type 691 Time Totalizer is an electrical stop clock which features instantaneous electrical reset (1/10

advance your fractional HP or Universal Electric Motor program with

MOTORK®

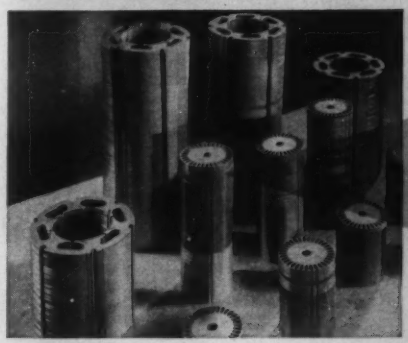
Laminations

Increased motor production,

lower inventories in your plant through flexibility and dependability of Motork production schedules and raw material supplies.

Improved motor performance . . .

designs can be held to closer limits for greatest unit cost reduction. Quality standards are assured by the Motork Evaluator.



Lowest motor core cost

by the use of equipment and metallurgical methods designed to put Motork 10 years ahead.

Careful studies of MOTORK Laminations in all common motor types have been made in Magnetic Metals Company laboratories. Results prove advantages of MOTORK over conventional laminations. Reports of these studies are available.

MAGNETIC METALS COMPANY

Hayes Avenue at 21st Street, Camden, N.J.

Electromagnetic Cores and Shields

Circle 523 on page 19

ZIP...

and another P-K fastener goes to work for famous Rheem water heaters

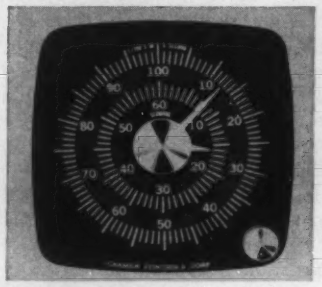
Fastening top and bottom pans and securing the decorative front panel on this 75-gallon Rheemglas Imperial water heater, takes only moments with Parker-Kalon fasteners. Rheem, America's largest manufacturer of automatic storage water heaters, chooses Parker-Kalon screws because they are fast, trouble free. They start right, drive right, hold tight.

P-K . . . the Original Self-tapping Screw . . . can keep *your* assembly lines humming, too . . . help keep rejects to a minimum. Ask your nearby Industrial Supply Distributor for samples and complete information.

PARKER-KALON®
fasteners

PARKER-KALON DIVISION, General American Transportation Corporation Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws. Factory: Clifton, New Jersey—Warehouses: Chicago and Los Angeles.

Circle 524 on page 19



sec) and accuracy within 0.01 sec. It is available in a dust-tight commercial model and a military type which meets vibration, shock, and environmental specifications. Available ranges are 60 sec in 1/100-sec divisions, 60 min in 1/100-min, and 60 min in seconds. Ratings include all standard voltages at 60 and 50 cycles, 115 v 400 cycles, and various voltages. **Cramer Controls Corp.**, Centerbrook, Conn.

Circle 752 on page 19

Silicone Rubber

withstands temperatures from −70 to 500 F

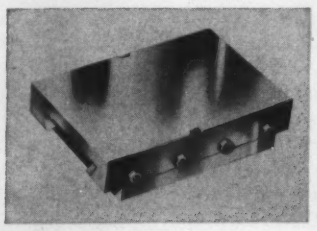
Silastic RTV room-temperature vulcanizing silicone rubber is for encapsulating electric and electronic parts, and for general potting, sealing, and caulking applications. It has a long shelf life in unvulcanized state, is easy to handle and blend, and retains rubberlike properties over temperature range of −70 to 500 F. Vulcanization takes place within 24 hr at room temperature, and compound is completely stabilized after 48 to 72 hr. **Dow Corning Corp.**, Midland, Mich.

Circle 753 on page 19

Slide Assemblies

in light and heavy-duty models

Line of slide assemblies includes 132 models in a broad range of types and sizes. Female member



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Get your cylinders *now*, when you need them. No need to lose production because of poor delivery! Carter will *ship your cylinder order in 24 hours or less*, to satisfy your needs. And when you buy Carter cylinders, you buy quality—rugged, dependable cylinders.

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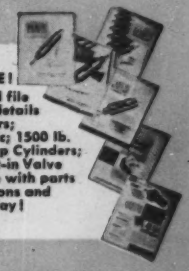
Order day or night. For fast service call CARTER: LANSING, ILLINOIS, GRanite 4-3305 or CHICAGO, BAyport 1-7186. TELETYPE LNSG, ILL 1119X.



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Complete bound file with ordering details for: Air Cylinders; 750 lb. Hydraulic; 1500 lb. Hydraulic; Clamp Cylinders; Air Valves; Built-in Valve Types. Complete with parts data, specifications and prices. Send today!

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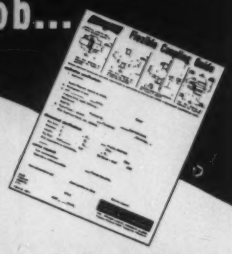
2914 Bernice Road • Lansing, Illinois (Chicago Suburb)
AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

Circle 525 on page 19

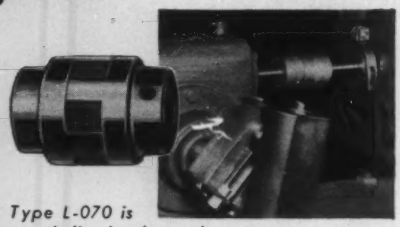
To Get The Flexible Coupling Best Suited For Your Job...

use the Lovejoy Flexible Coupling Guide

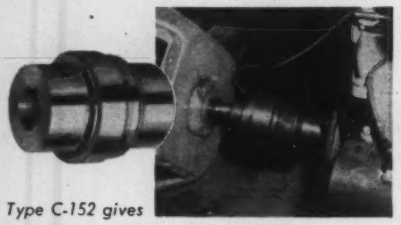


Save time, money and mistakes, insure trouble-free performance . . . by using the Lovejoy Flexible Coupling Guide. You'll get the exact type and size for your particular application —*plus all these Lovejoy features:*

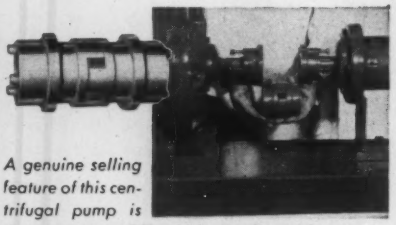
- No lubrication required.
- Simple, rugged construction—few parts, no intricate mechanisms.
- No wear on metal parts—the load is transmitted through cushions only.
- Double-life cushions—one half the cushions act as idlers, except on reversing loads. Thus, a quick interchange provides a new set of cushions.
- Cushions engineered to load and service conditions.
- A maintenance-free coupling that is completely machined for ease and speed of alignment.



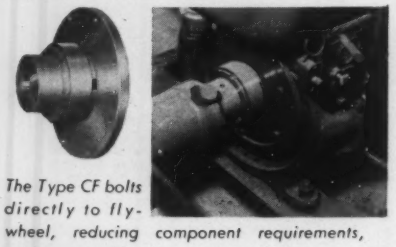
Type L-070 is exactly fitted to the requirements of this gear pump.



Type C-152 gives maintenance and trouble-free performance in a portable power unit.



A genuine selling feature of this centrifugal pump is the spacer type RRL which permits quick, easy disassembly without disturbing piping. (Courtesy Dean Brothers Pumps, Inc.)



The Type CF bolts directly to flywheel, reducing component requirements, cutting assembly time and providing a more compact unit.

- **Act now! Send for your Flexible Coupling Guide today.**

REQUEST CATALOG

LOVEJOY FLEXIBLE COUPLING CO.

4818 WEST LAKE STREET • CHICAGO 44, ILLINOIS

New Parts

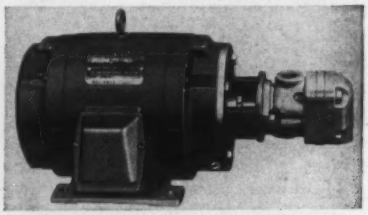
slides on dovetail ways, with clearance accurately regulated by a steel gib. High-tensile grey-iron castings, heat treated to eliminate distortion, are machined and ground parallel top and bottom. Offering stroke lengths from ¾ to 4 in., light-duty slides have working surfaces from 2 x 3 to 6 x 16 in. Heavy-duty slides provide maximum rigidity, permit longer overhang, and have a heavier section for mounting tools and fixtures. Stroke lengths from 2 to 8 in. are available, with working surfaces from 4 x 8 to 8 x 24 in. **Russell T. Gilman Inc.,** 623 Beech St., Grafton, Wis.

Circle 754 on page 19

Motors

for hydraulic pumps

New motors, in sizes from 1 to 200 hp, are used to power hydraulic pumps, and are employed wherever a prime mover for hydraulic fluid components is required. They are



available in all standard enclosures, and have single or double shaft extensions for mounting pumps at one or both ends of motor. Motors incorporate NEMA-C-face with shortened shaft and pump-mount bracket to save installation space. **Reliance Electric & Engineering Co.,** 24701 Euclid Ave., Cleveland 17, Ohio.

Circle 755 on page 19

Lock Washer

is a self-sealing, self-locking unit

Dubo-Ring lock washer provides positive locking and sealing action by incorporating a symmetrical ring in a double-V shape. Washer has no threaded parts, and is simple to fit over any type of screw or bolt. ID of washer grips into threads of bolt and nut and flows into opening of

STAINLESS STEEL

CORROSION-RESISTANT HEART FOR FOSTORIA* MAGNETIC PUMPS

Design of Fostoria's Dynapump called for a corrosion and wear resistant hollow shaft, with drilled slots in one end. As an integral part of the pump, dimensional accuracy was critical and the O.D. had to be ground to provide a smooth bearing surface. Damascus 7/8" x 16 gauge stainless welded tubing was selected — a wise choice for handling both corrosive and non-corrosive fluids.

**The Fostoria Pressed Steel Corporation, Fostoria, Ohio, manufacturers of pumps for industrial and residential use.*

DAMASCUS TUBE COMPANY
STAINLESS STEEL TUBING AND PIPE
GREENVILLE, PENNSYLVANIA

WELDED STEEL TUBE INSTITUTE

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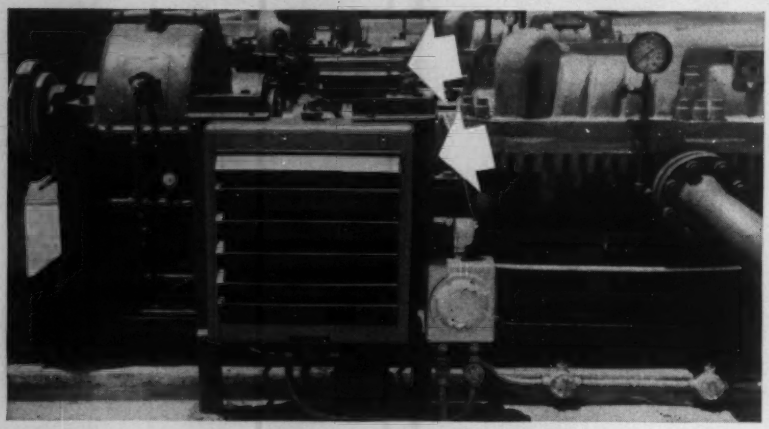
No room for failure here!

Young Engineering insures "round-the-clock" service



Two Young "OH" oil cooling units are identified above. Right foreground is the nine-stage centrifugal pump.

Okan Pipeline Company relies on Young design and construction to provide uninterrupted cooling

The superior design and construction of Young "OH" oil coolers insures uninterrupted service on this vital six-inch high pressure LP-Gas pipeline, running from Southwest Kansas to Tulsa, Oklahoma.

Young Turbulators and other exclusive patented features provide maximum heat transfer with minimum pressure drop for the nine-stage centrifugal pump, powered through a speed increaser by a Waukesha VLROBU twelve cylinder gas engine. Control of temperatures of the 30 gallons of cooling oil in the speed increaser and pump bearings is by thermoswitch, activating the fan motor of the oil cooler when the temperature goes above 160° F.

The unmatched experience of Young engineers reduces "difficult" problems to matters of standard procedure. Consult Young Radiator Company on all heat transfer problems and write today to Dept. 307-K for catalog 3555-A. Representatives in all principal cities. There is no obligation.

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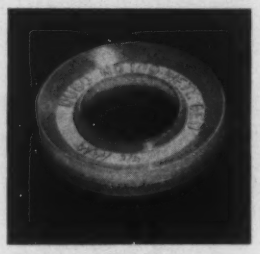
RACINE, WISCONSIN

Creative HEAT TRANSFER ENGINEERS

Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

New Parts



tapped hole. OD flows over outer edges of nut, locking and sealing it. Action is unaffected by vibration or shock. Washer, of Nylon 6, is reusable without diminishing locking and sealing powers. It has uniform locking torque and low installation torque, with no galling or seizing on mating threads. Form is stable to 420 F, and tensile strength is over 10,000 psi. **Nylogrip Products,** 449 Watertown St., Newton, Mass.

Circle 756 on page 19

AC Potentiometer

for servo and control systems, and analog computers

Model 3B Vernistat combines functions of an ac potentiometer and an autotransformer. It provides 0.01 per cent linearity in a unit built into a size 18 synchro housing. A 30-turn potentiometer, it has an output impedance of 30

ohms. Unit is for use in servo systems, control systems, and analog computers. **Perkin-Elmer Corp.,** Danbury Rd., Norwalk, Conn.

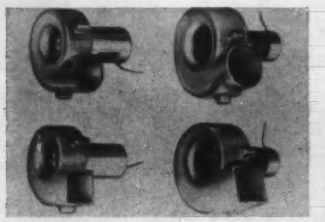
Circle 757 on page 19

Miniature Blowers

centrifugal units have high output

Miniature dc centrifugal blowers incorporate a cast-aluminum scroll, providing ruggedness, protection against extreme environments, and large air outputs. Units have 1½

or 2-in. rotors, and both clockwise and counterclockwise scrolls are available with rectangular or round outlets for ducting. Scrolls also provide excellent radio noise shielding, and interior wall smoothness permits low-loss air delivery. Free-air delivery for 1½-in. size is 18-20 cfm, and the 2-in. size delivers 36 cfm. Motors meet military radio noise and environmental specifica-



tions, and operate on a wide range of dc voltages. Weight of blowers ranges from 8.25 to 13.75 oz. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, Ohio.

Circle 758 on page 19

Insulating Material

for electrical and mechanical uses

Spauldo thin insulating material is of 100 per cent rag stock with glazed finish. It combines high dielectric strength with flexibility and edge-tearing resistance. A ⅛-in. cuff can be formed along the edges of coils or strips to keep cells in position for effective insulation at both ends. Material is noncorroding, and is suitable for use in hermetically sealed motors. It is available in strips, coils, rolls, sheets, or fabricated parts. **Spaulding Fibre Co. Inc.**, 310 Wheeler St., Tonawanda, N. Y.

Circle 759 on page 19

Low-Pressure Switch

controls or signals small pressures and vacuums

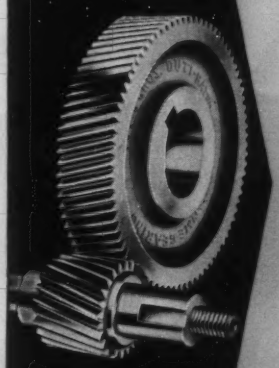
Low-pressure switch is suited for control of movement of roll-type air filters, pressure regulation of gas boosters, switch operation of dampers, blowers, gas-fired heaters, and for similar low-pressure control, safety, or signaling applications. Independently adjustable automatic reset extends use of

(*Please turn to Page* 214)

PREMIUM GEARING
at Production-Run Prices

Foote Bros. Offers Engineered Helical and Worm Gear Sets FROM STOCK

1638 Duti-Rated COMBINATIONS



IN STOCK:

*Horsepower Ratings....1 to 200**
*Center Distances.....2" to 12"**

Check with Foote Bros. *before* you finalize that design. The chances are you'll find exactly what you need among the 1638 *stock* combinations of Duti-Rated Helical Gears.

When you buy Duti-Rated Gearing, you'll get more than best for your money . . . you'll get the benefit of thousands of engineering and development hours . . . and the unquestioned advantages of precision tooling and manufacturing methods. You'll get performance proven in countless Foote Bros. Line-O-Power and special drives, and Foote Bros. —Louis Allis Gearmotors. This is high hardness, accurate, balanced design gearing that will give you more load capacity and wear life per dollar.

**Larger sizes made to order from standard tooling.*

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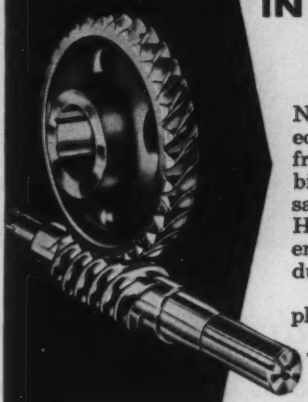
150 WORM GEAR COMBINATIONS



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Need worm gear and worm sets? There is economy and convenience in choosing them from the many Foote Bros. worm gear combinations available from stock. This is the same gearing used in famous Foote Bros. HYGRADE Enclosed Worm Gear Drives . . . engineered, premium quality gearing at production-run prices.

Engineering Manual SW No. 1 has complete details. Write for your copy.

† Tooling available for larger worm gear sets, engineered, but not stocked, to 200 HP and 18" centers. Prompt deliveries.

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Let us help you select standard helical or worm gearing to meet your special requirements, or, let us design and build your complete unit. Place your gear problems in the hands of experienced power transmission and gear engineers. Your inquiry is invited, and there's no obligation.

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FOOTE BROS. GEAR AND MACHINE CORPORATION
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Circle 529 on page 19

variable speed with new versatility and performance

A triumph of new Motodrive design . . . inside and out

New REEVES Vari-Speed Motodrives, sizes 200 and 300, are complete variable speed power packages, built with compactness and precision, to give improved performance on installations 1 through 5 hp.

The new sizes are designed in two styles—"C" flow and "Z" flow. In each style, there are several different models and reducers with increased capacity in single, double or triple stages.

The flexible design permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements.

The handwheel control location can be rotated to optional positions for greater operating convenience; extra precision of control is available with the addition of one or more REEVES accessories or modifications.

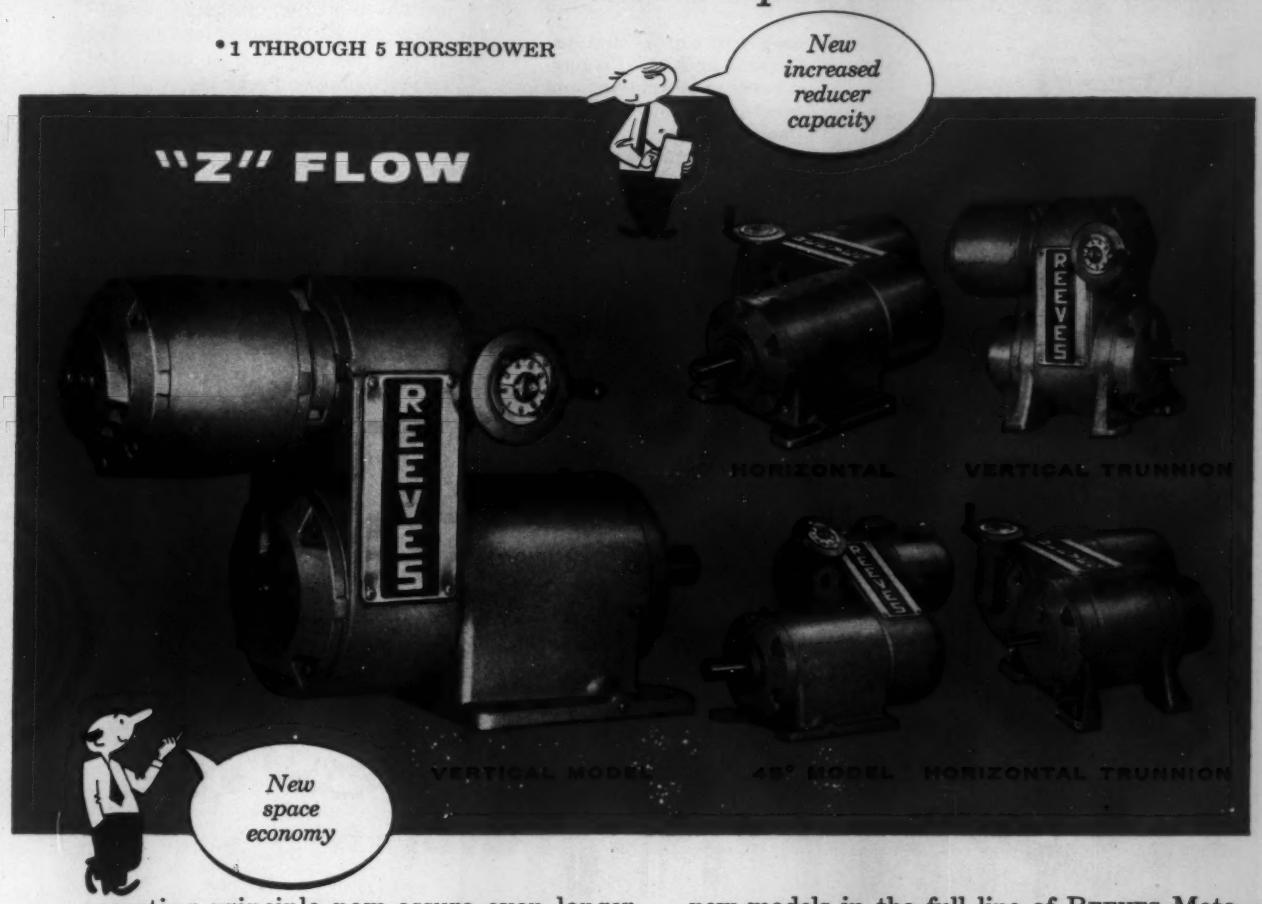
Refinements to the time-tested REEVES

NEW

REEVES®

*Sizes 200-300 Vari-Speed MOTODRIVES**

*1 THROUGH 5 HORSEPOWER



operating principle now assure even longer trouble-free service.

New disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Sizes 200 and 300 are versatile, hard-working new models in the full line of REEVES Motodrives which provide instant and accurate variable speed control on ¼ through 40 hp. applications.

Complete details, dimensions, illustrations and prices on assemblies, modifications and accessories are in Catalog H31b-M571. Write for your free copy today.

REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

Circle 530 on page 19

IT PAYS TO HAVE HUBBELL GOOD CONNECTIONS

PRECISION MACHINE SCREWS

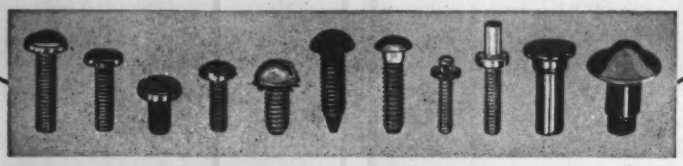
Make it Easier to Sell!

. . . because with high quality fasteners your product earns a reputation for better performance and longer life service. Experience proves that the initial higher cost of quality components is offset time and time again by such things as operating efficiency, good appearance, better accuracy, etc.

Better Steel means Better Quality

The carbon steel heading wire used in the production of standard Hubbell Screws is A.I.S.I. Grade C-1010. Special application screws with higher strength or torque value requirements are produced from A.I.S.I. Grades C-1013, C-1020 and C-1035. Those subjected to drilling or subsequent tapping operations are produced from A.I.S.I. Grades C-1108 or C-1110.

All carbon steel wire used in the production of Hubbell screws, regardless of grade, is annealed in process material to specified tensile strength and is drawn to restricted size tolerance to insure the high Hubbell standards of quality and size in the finished screws.



Prices and delivery on request. Simply send blueprint or sample of the item.

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OVER 60 YEARS' EXPERIENCE in the manufacture of highest quality, rolled thread machine screws and special cold headed parts.

MACHINE SCREW DEPARTMENT BRIDGEPORT 2, CONNECTICUT

Circle 531 on page 19

New Parts

(*Continued from Page 211*)

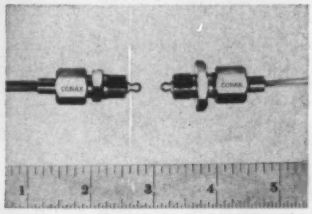
switch to many automatic control applications. Unit can be mounted in any position, and is unaffected by vibration. Pressure, vacuum, or differential pressure operate the switch. Normal range is from 0.1 to 5.0 in. water, and make and break contacts are adjustable to any point within this range. Switch operates on ac and dc to 110 v. **Bacharach Industrial Instrument Co.**, 200 N. Braddock Ave., Pittsburgh 8, Pa.

Circle 760 on page 10

Thermocouple Gland

is less than 1½ in. long

Miniature thermocouple gland provides a positive seal for bare wire thermocouples from 0.005 mu to 5000 psi. Small, compact design permits use where space is limited. Temperatures can be checked accurately from −300 to 1850 F at a time constant of less than 1 sec. Gland is Type 303 stainless steel,



and is available with standard ⅛-in. taper pipe thread or standard aircraft thread AND 10056-4. **Conax Corp.**, 2300 Walden Ave., Buffalo 25, N. Y.

Circle 761 on page 19

Fastener

has spring-tension legs for blind assembly

Speed Clip fastener has spring tension in legs plus retaining tabs to permit prepositioning for blind assembly. Spring tension of clip also

Illustrated—Logan Model 400 RFL Unit

Look to Logan

the ultimate in air circuit accessories

Logan RFL Unit, the designers choice for over a decade! Protects your air-powered equipment . . . regulates pressure . . . filters air . . . lubricates air. Adds years of dependable performance.

New Model 400, illustrated above, is a companion model to the well-known Model 600.

FREE SEND FOR THE "LOGAN CALCULATOR"

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TO:

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COMPANY _____

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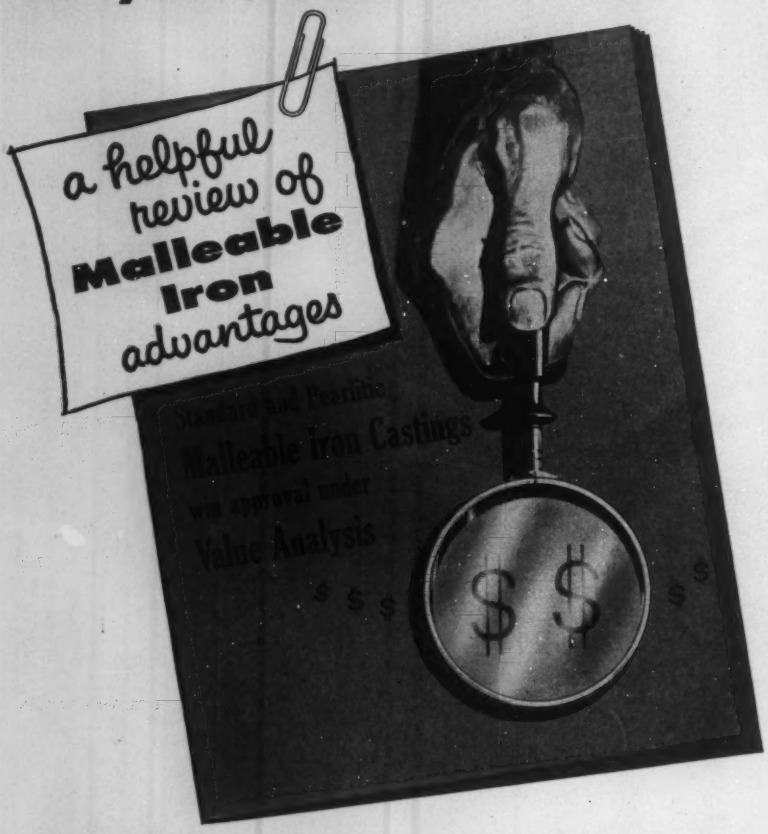
Circle 532 on page 19

For your metals data file . . .



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Whether your approach to selection and purchasing is "Value Analysis", "Purchasing Research", "Cost Reduction Buying" —or just plain "wise buying", the need for background information on materials is apparent to both designers and purchasing people.

How about Malleable?

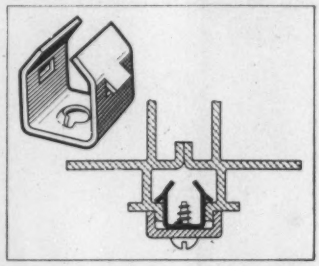
This new publication— "Standard and Pearlitic Malleable Iron Castings win approval under Value Analysis"—is now available to you. It shows you how the use of Malleable will pay big dividends. Just write for the "Value Analysis brochure".

Consult a malleable foundry engineer at the drawing board stage

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building Cleveland 14, Ohio

New Parts



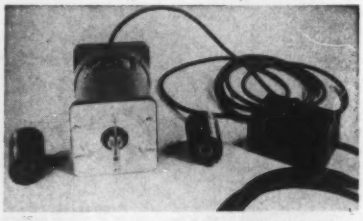
reduces possibility of loosening due to vibration. Application shown here (right), illustrates typical use in extruded-aluminum door or window sashes. **Tinnerman Products Inc.**, P. O. Box 6688, Cleveland 1, Ohio.

Circle 762 on page 19

Motors

provide accurate remote power positioning

Two new motors provide accurate power positioning without feedback reference. One is a step motor (shown) which indexes in 60, 30 and 15-deg or smaller steps; the other is an induction motor which provides continuously adjustable power positioning. Both motors can be applied with tape control mechanisms for operating machine tools, for incremental in-



dexing of computers and digital systems. Motors can be operated as polyphase induction motors as well as for power positioning. **B. A. Wesche Electric Co.**, 1628 Vine St., Cincinnati 10, Ohio.

Circle 763 on page 19

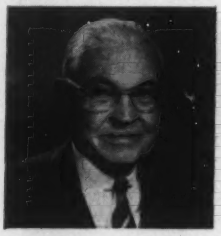
Time-Delay Relays

miniature units have delay from 0.01 to 60 sec

Typical applications of miniature time-delay relays include aircraft and missile instruments and controls, navigation systems, automation circuits, and computers. They incorporate transistors and RC

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities

By John S. Davey

Fastener coatings

Salt spray testing of various metallic coatings used on fasteners doesn't always give a true picture. In actual service, accelerated test results are not always borne out.

Reason: The tests favor the coatings which can endure continuous moisture and salt atmospheres, whereas some do better under the normal intermittent dry and wet conditions of weathering.

Experience has developed a "scale" of suitability of various coatings for fastener protection.

FOR RUST PROTECTION

Hot galvanizing offers greatest endurance under most conditions. It falls short on highly stressed fasteners.

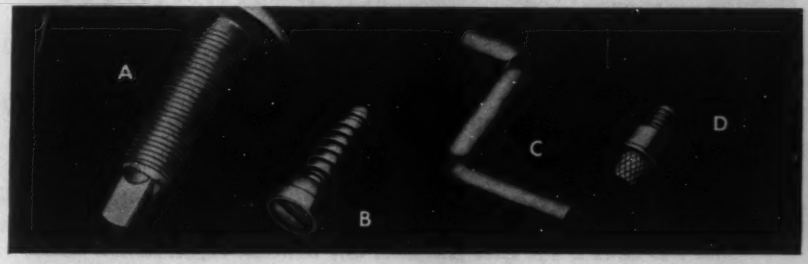
Electrodeposited zinc is next most practical—providing good appearance, controlled tolerance at threads, and ability to take high bolt tensions.

Cadmium plate stands out where salt atmospheres predominate. Not suitable for contact with edibles, it is ruled out for many appliances.

For general applications, the rust prevention of black oxide coatings proves satisfactory. Phosphate coatings, too, offer some degree of protection, but not under severe conditions.

Chromium, plated over copper, should be considered more for its appearance on fasteners rather than protection.

Cold heading creates quality parts the low cost way



No value analysis of product components is really complete without exploring what cold heading machines can do to cut costs. Some examples:

A. ELIMINATE EXTRA OPERATIONS. Leveling screw, formerly made by riveting flat disc to set screw, now emerges as a stronger, single piece from a cold header.

B. ONE PIECE BETTER THAN TWO. Cold headed hose clamp screw has integral flange which, after head is slotted, is forced up to form screwdriver shield. Before, piece was in two parts . . . with screw made on screw machine, and the shield a stamping fitted around head during assembly.

C. FASTER THAN FORGING. Shifter lever is bent into double "L" automatically in bolt header . . . replacing 2-stage forging operation. The header does it at high speed from continuous rod.

D. METAL *FLOWS* TO SHAPE—NO WASTE. No longer cut on screw machine, insert screw for plastic parts costs 40% less. Cold header uses just the amount of metal required. The threading and knurling, too, are done automatically at high speed.

Metal forced to cold flow into shape results not only in savings but also in stronger parts. With uncut flow lines, the piece is better able to withstand stress concentrations.

For an expert opinion on parts you now use, check with Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

12-point fasteners cut wrench clearance space

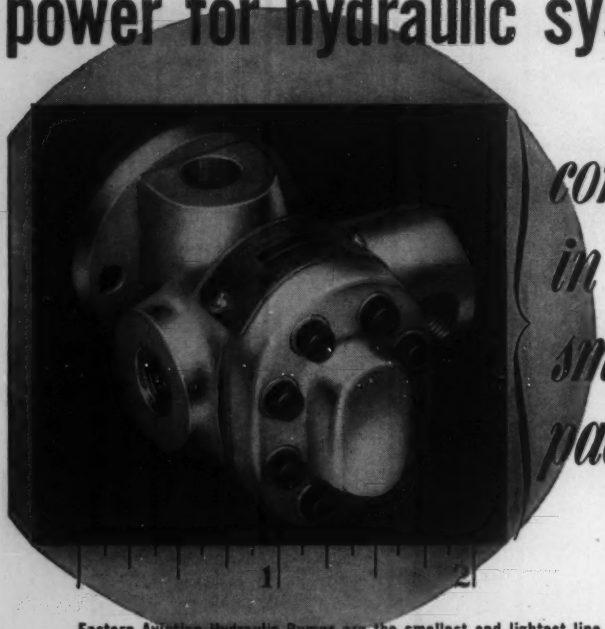
Double hex RB&W bolts and nuts measure smaller across their points than single hex fasteners. Used with an *external* socket wrench, they permit optimum driving torque to be applied.

Thus, while permitting design of more compact assemblies, these fasteners also assure proper preloading for stronger connections.

Available with plain flange, or SPIN-LOCK design which incorporates teeth that embed upon tightening and resist loosening under vibration or temperature changes.

Circle 534 on page 19

power for hydraulic systems



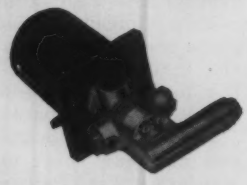
comes in small packages

Eastern Aviation Hydraulic Pumps are the smallest and lightest line of pumps ever made. They supply as much as one gallon of fluid per minute against pressures as high as 2000 PSI.

The 1700 Series of high speed gear pumps have theoretical displacements varying from .0021 to .0251 cubic inches per revolution. This series of pumps can be close-coupled directly to various electric motors. They are made in many configurations with and without integral bypasses. A variety of bearing combinations handle different types of fluids and operating pressures.

Eastern engineers can adapt and design hydraulic pumps to meet your specifications. On your next project, contact Eastern for engineering help that really helps.

Eastern 1700 SERIES PUMPS



1733-HBU-249

1731-LCU-205

1781-HBV-255

1700 SERIES PUMP

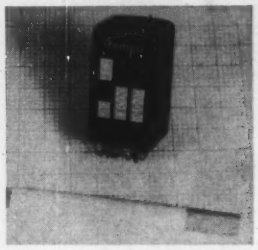
Send for Aviation Bulletin 340

Eastern INDUSTRIES, INC.

100 SKIFF ST. • HAMDEN, CONN.

New Parts

time-constant circuits, eliminating all moving parts except relay contacts. Standard models have time-delay periods from 0.01 to 60 sec, with delay occurring between application of current and pull-in of relay contacts. Timing accuracy is ±10 per cent of nominal through temperature range of −55 to 125 C. Units are vibrationproof



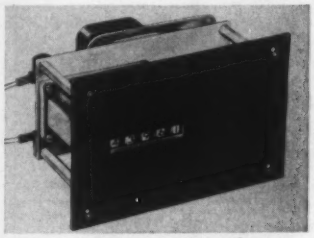
to 20 g and 2000 cps, and withstand shock of 40 g for 11 millisec. Design provides instantaneous recycling, with constant delay period regardless of number or frequency of operations. **Tempo Instrument Inc.,** 240 Old Country Rd., Hicksville, N. Y.

Circle 764 on page 19

Data Readout Counter

combines visual indicating with electrical readout

Electrically or mechanically driven, manual or electric-reset counter combines visual indication with electrical readout for remote indication, recording, and control applications. It presents a positive



display of accumulated totals and automatically creates specific control-circuit contact closures for each number visually displayed. Having a five-figure capacity, counter provides 100,000 distinct circuit arrangements for control and transmission applications. Counter is compatible with standard data-processing equipment. Pictured is Model B-1538, an electrically actuated unit with electri-

Circle 535 on page 19

NEW GOLDEN BONDERITE for Aluminum

Uniform color means uniform coatings and uniform efficiency

It's the simplest thing in the world to check on the efficiency of a Golden Bonderite installation. Just look at the color of the aluminum as it comes out of the Bonderite machine. The uniform golden coating looks the same—and it is the same—24 hours a day, seven days a week.

Golden Bonderite sets entirely new standards of efficiency and performance as a paint base for aluminum and its alloys. Operated with the Parker "Reactifier," the Golden Bonderite solution can be used indefinitely, ending the costly necessity of dumping the bath at frequent intervals. Normal chemical replenishment keeps the Golden Bonderite solution in continuous balance.

This ease and certainty of achieving uniformly excellent results means real savings for aluminum fabricators.

It guarantees an effective base for paint.

It breaks the finishing line production bottleneck.

It saves money on chemicals.

It saves money on rejected parts and minimizes field calls because of finish failures.

There are no limitations on the use of new Golden Bonderite. It may be applied by spray or immersion. Treatment cycles can be set to suit production speed and equipment.

Samples of Golden Bonderite-treated aluminum, plus test data, are available for your inspection. Write or call.

How Parker "Reactifier" Works

In conventional surface treatments of aluminum, work passing through the solution causes a buildup of impurities. As impurities increase, solution efficiency decreases until there's nothing to do but dump the bath and start over.

The Parker "Reactifier" removes these impurities as fast as they are formed in the Golden Bonderite solution. Constant circulation of the Golden Bonderite through the exclusive "Reactifier" means a balanced, efficient solution that can be used indefinitely.

Write for Bulletin in COLOR!

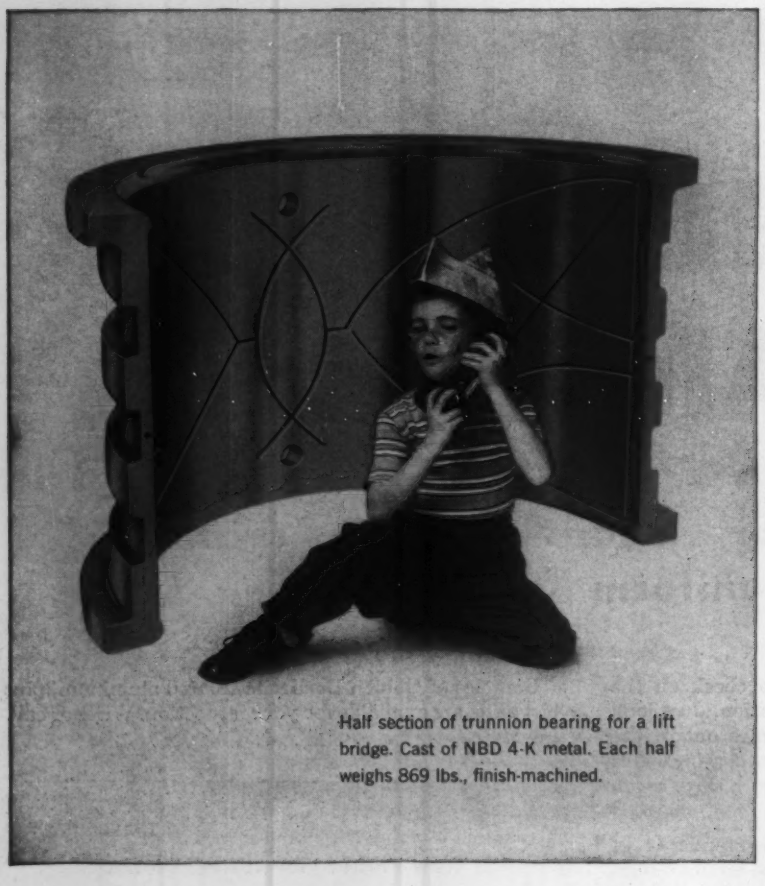
Get your copy of the descriptive bulletin on Golden Bonderite and its companion, Green Bonderite, for aluminum. It's new!

Since 1914—leader in the field

PARKER RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite, —Reg. U.S. Pat. Off.*



Half section of trunnion bearing for a lift bridge. Cast of NBD 4-K metal. Each half weighs 869 lbs., finish-machined.

CALL IN **NBD**
FOR BIG **BRONZE**

Need "big bronze" like this, with oil holes and grooves cast right in? We cast and machine them to tolerances precisely held to your specifications. That's one advantage you gain through NBD's unsurpassed knowledge of casting techniques and machining facilities.

On smaller sizes or production runs, too, you can depend on top quality from NBD. Our specialty is bronze metallurgy . . . we've developed more than 40 special alloys. And we're completely equipped for shell-mold, cast-to-size, centrifugal casting . . . as well as sand casting.

For bearings, bushings, gear blanks, pump parts, call or write us for quotes or information.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
717 Grant Building • Pittsburgh 19, Pennsylvania
PLANTS IN: CHICAGO • ST. LOUIS • MEADVILLE, PA.

New Parts

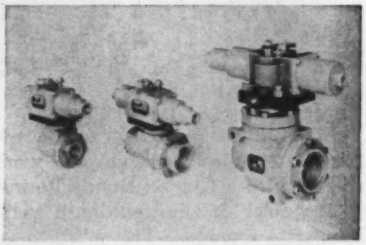
cal reset. It operates on 110 v ac or dc. **Veeder-Root Inc.**, Hartford 2, Conn.

Circle 765 on page 19

Shut-Off Valves

for low-temperature, high-pressure applications

Lightweight, pressure - operated shut-off valves are available for line sizes from ¼ to 3 in. Floating ball-seat valve arrangement has self-wiping and self-lapping action. Units provide bubbletight flow control through a cryogenic media temperature range of −320



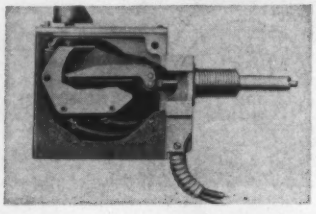
to 200 F, at pressures to 3000 psi. Valves are available with response times as fast as 25 millisec for full stroke travel. They meet shock and vibration requirements of MIL-E-5272A. **Hydromatics Inc.**, 70 Okner Parkway, Livingston, N. J.

Circle 766 on page 19

Immersion-Type Thermostat

provides close temperature control

Thermostat is for use where a sensitivity of temperature change as low as a fraction of a degree exists. It maintains close temperature control to 300 F, and withstands extreme temperatures above or below calibrated range. Thermal element is composed of a metal tube surrounding a steel rod. Differential expansion of the two metals, connected with proper leverage, operates a snap-acting switch. Adjustment of temperature setting



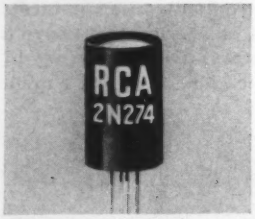
is accomplished by turning a knob to desired degree within calibrated range. Unit can be mounted in any position. **Alloy Bellows Inc.,** 18125 Roseland Rd., Cleveland 12, Ohio.

Circle 767 on page 19

High-Frequency Transistor

for radio-frequency amplifier service

Small, hermetically sealed drift transistor, designated 2N274, is a germanium p-n-p type. It is designed for radio-frequency amplifier service in compact military, mobile, and communications equipment, and in entertainment-type receivers operating at frequencies covering AM broadcast and short-wave bands. It is also suitable for use as an intermediate-frequency amplifier or mixer-oscillator. Unit utilizes shielding to minimize interlead capacitance between collector lead and base lead, and to minimize coupling to adjacent circuit



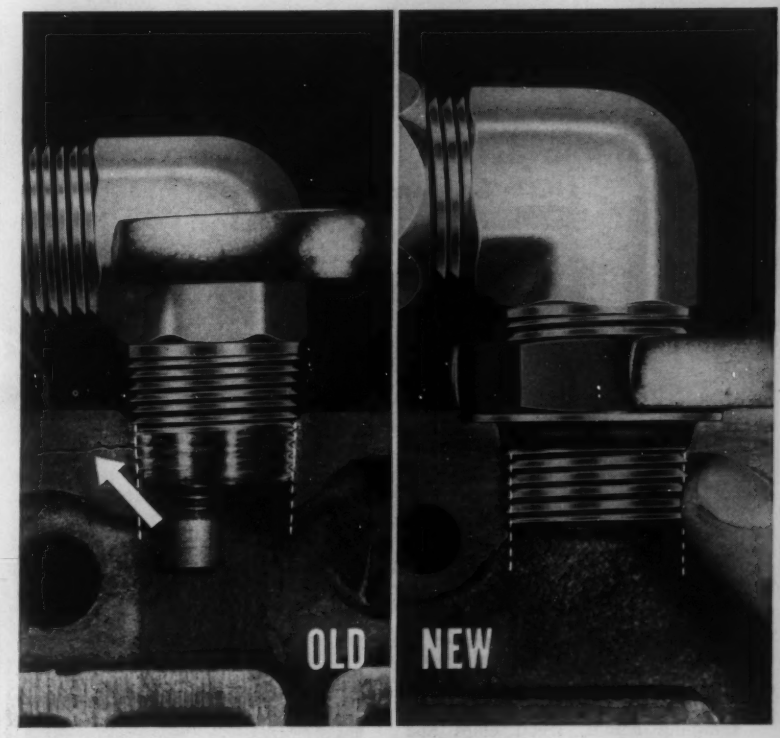
components. It has low collector transition capacitance, collector dissipation of 35 mw maximum, and high power gain. **Radio Corp. of America,** Semiconductor Div., Somerville, N. J.

Circle 768 on page 19

Electromagnetic Brakes

have minimum brake torques from 2 to 30 oz-in.

Servo - mounted electromagnetic brake, when energized, permits output shaft to rotate free. When not energized it is a brake, allowing a servomotor to be braked with power on. It can also be used to lock one of the output shafts in a differential gear while the other output is transmitting a controlled motion. Small size and light weight make unit useful for airborne applications. Four sizes have minimum brake torques from 2 to

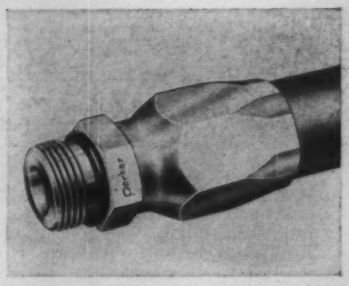


How Parker straight-thread fittings solve leakage problems

Forget about danger of cracking or distorting valve bodies by overtightening the fittings. Forget about messy pipe "dope." Forget about leakage problems resulting from tapered pipe threads in high-pressure hydraulic systems.

Eliminate these problems. Use Parker O-ring seal straight-thread fittings (which conform with the SAE Standard for Hydraulic Tube Fittings) for leakproof, trouble-free connections. Available on both *Triple-lok* (see Catalog 4310) and *Ferulok* (Catalog 4320).

Ask your Parker Distributor today for catalogs or write to —



New, Broader Line of *Hoze-lok* fittings for medium- and high-pressure hydraulic service. No skiving of hose cover. Easier make-up saves time and money. Longer performance, greater re-usability. Catalogs 4433 and 4434.

TUBE AND HOSE FITTINGS DIVISION, Section 435-V
The Parker Appliance Company
17325 Euclid Ave., Cleveland 12, Ohio

Parker
Hydraulic and fluid system components

Circle 538 on page 19

VALLEY BALL BEARING **MOTORS**

Custom Built . . .
NOT Custom Priced !

AIR COOLED

- POLYPHASE, 50 OR 60 CYCLES
- SQUIRREL CAGE INDUCTION
- HIGH TORQUE
- ½ TO 75 H.P.

Cool Running . . . Continuous Service . . .

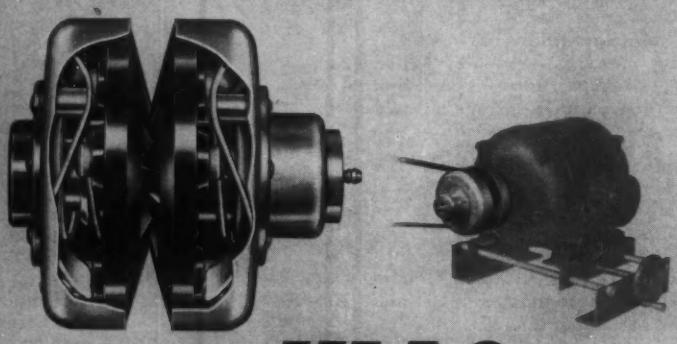
that's the axiom Valley Motors live up to.
They have been tested and proven in every industry where dependable service and power is a requirement. Remember they are semi-enclosed to assure protection against dripping or splashing liquids, metal chips and abrasive dust.

WRITE FOR COMPLETE INFORMATION

VALLEY
ELECTRIC CORPORATION
4221 Forest Park Blvd • St. Louis 8, Mo.

Circle 539 on page 19

striving for ***SIMPLICITY?***



here's how ***HI-LO*** *helps*

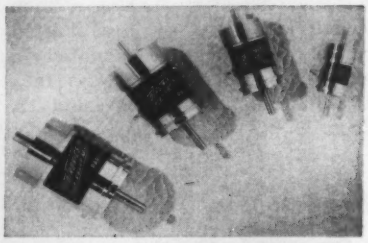
Design-wise, HI-LO automatic variable speed pulleys help you reduce complex design problems. Functionally, they're first choice of many design engineers for a wide range of applications. The simple, positive action of cam followers on cams is the mechanical action that takes place in maintaining the pitch diameter setting regardless of load—an exclusive feature of HI-LO pulleys. Springs in HI-LO pulleys are not driving members as in most spring-loaded pulleys, but serve primarily to keep the pulley faces in contact with the belt.

For *FREE* technical manuals with diagrams, descriptions of applications and other power transmission data, write:

Equipment Engineering Company
2855 Columbus Ave., Minneapolis, Minnesota

Circle 540 on page 19

New Parts



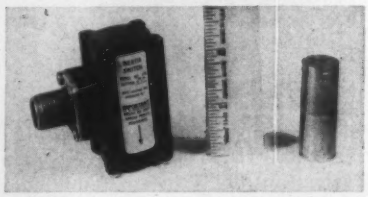
30 oz-in. and weights from 0.74 to 7.3 oz. Standard models operate at 24 v dc. All units meet vibration requirements of MIL-E-5272A. **Autotronics Inc.,** Route 1, Box 812, Florissant, Mo.

Circle 769 on page 19

Inertia Switch

miniature unit has one frictionless moving part

Compact inertia switch is suited for applications where space and weight are critical factors, such as in aircraft and missiles. One single moving part, frictionless in operation, momentarily closes electrical contacts when subjected to impact or acceleration above a preset value. Switch setting is easily adjustable from 1.5 g minimum,



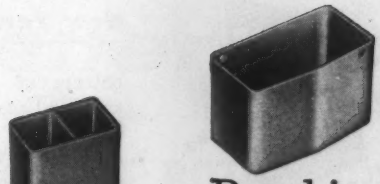
with tolerance of ±0.15. Shown are Model 510 ready for installation (left) and Model 410, inertia cartridge alone (right). **Safe Lighting Inc.,** 527 Lexington Ave., New York, N. Y.

Circle 770 on page 19

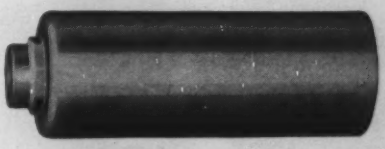
Hydraulic Hand Pump

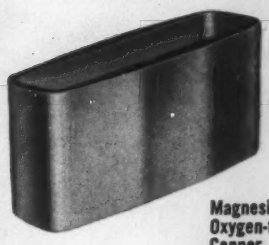
has rated output pressure of 10,000 psi

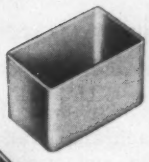
This pump can be used with any oil, water, or fluids which will not attack cast iron. It can also be used with dirt-laden fluids, and permits no external leakage. Pump uses standard hand-pump lever and is available in three lever positions. Lever swings through 60 deg per stroke and piston leaves less than 0.25 per cent unswept volume at

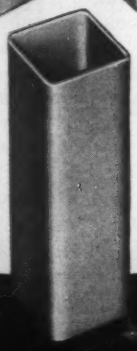


Breaking fabrication barriers in new materials with cold forging!









Magnesium, Oxygen-free Copper, Zirconium, High Strength Aluminum Alloys

Most companies and engineering personnel are well acquainted with Hunter Douglas' activities in the field of cold forging aluminum and aluminum alloys. Not so well known are our efforts in the production of magnesium and oxygen-free copper components by the same process. Recently, as the result of a concentrated Hunter Douglas research program, tubular zirconium was successfully cold-forged...an achievement which now opens the door to the fabrication of other rare and costly metals by our cold forging techniques.

The field of cold forging is constantly expanding with many new successes destined for the future.

Where stakes are high and being "first" assures a competitive advantage—in lower cost, better design, greater strength—an original approach to your fabrication problem will pay dividends.

Hunter Douglas cold forging techniques, backed by an unmatched experience in this field, frequently supply the missing key. Many fabrication problems can be solved simultaneously by producing hollow, dense, zero-draft components meeting exact part geometry requirements and difficult performance specifications.

If you have production requirements in any of the metals now being regularly cold forged, we welcome the opportunity of reviewing prints and submitting quotations. Especially important, *if you have an advanced program involving zirconium or other rare metals*, we are in position to devote development facilities to the solution of specific high priority problems.

Among Hunter Douglas' many achievements is the first successful cold forging technique for zirconium ...a metal long believed unresponsive to this process!

By cold forging, the hard surface oxides, carbides and nitrides normally produced by hot working were completely absent, surface finish was good, and in tubular shapes tolerances on diameters and concentricity were held to a few thousandths... far superior to hot extrusions. With almost complete elimination of machining, metal waste was negligible... an extremely important factor with material costs running as high as $20.00 per pound!

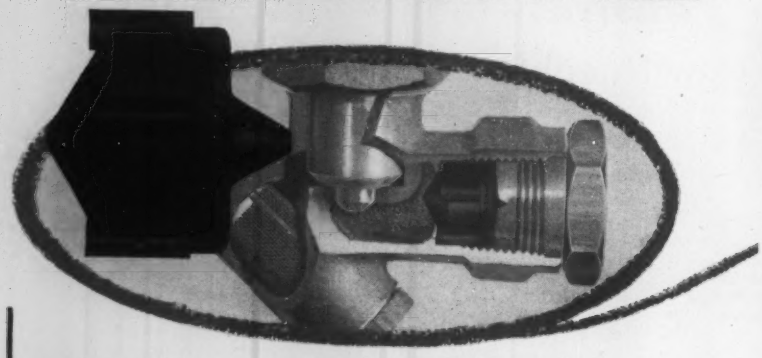
Cold forging of oxygen-free copper is now proving important to the electronics industry and experimental development work is in progress on magnesium and even common metals, such as steel. Out of this extensive research program is coming the vital knowledge for meeting tomorrow's unusual problems. Look to Hunter Douglas for everything new in cold forging!

Hunter Douglas Aluminum
Division of BRIDGEPORT BRASS COMPANY
Dept. MD-10, Riverside, California, Telephone OVerland 3-3030

Circle 541 on page 19

THE SHAPE OF THINGS IN MOLDED RUBBER

MOLDED DIAPHRAGM
GIVES TOP PERFORMANCE IN WATER



APPLICATION:
The diaphragm shown here is the heart of a precision water flow control device for use in various appliances where automatic water flow control is necessary. It automatically maintains one set water flow regardless of inlet pressures or temperatures. This new unusual device is manufactured by a company famous for supplying brass and iron products for the water, gas and plumbing industries.

PROBLEM:
This diaphragm, less than 1" in diameter, must withstand pressures from 10 to 150 lbs. psi. and guaranty water delivery within 10% ± of the valve rate capacity. The diaphragm must also flex in temperatures ranging from 50°F. to 150°F. Mold it and make it work!

SOLUTION:
Acushnet engineers designed and used an injection mold to obtain the necessary precision. Strict production controls were instituted to maintain high quality parts. All neoprene stock prior to molding was checked for physical properties and weight. Samples were taken from every heat for flow tests approximating five days. For extra quality control, stocks that did not produce parts to the spec were scrapped. Acushnet now molds a complete line of precision neoprene diaphragms for this customer.

Acushnet offers complete under-one-roof facilities for the accurate compounding, engineering and precision molding of rubber, silicone and silicone resin parts. Apco technical representatives located in key industrial areas are ready to help you with your problem.

Send for Acushnet "Rubber Data Handbook."

What's Your Shape?

Acushnet

ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS

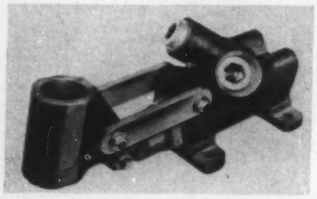
... *Precision Molded* RUBBER, SILICONES - "APCOTITE" BONDING

Address all communications to 762 Belleville Ave., New Bedford, Mass.

Circle 542 on page 19

New Parts

bottom of stroke. Output pressure and pressure produced with a 63-lb load on the end of a 28-in. lever is 10,000 psi rated, usable to 15,000 psi. Rated displacement



is 0.2 cu in. per stroke. **Gladden Products Corp.**, 635 W. Colorado Blvd., Glendale 4, Calif.

Circle 771 on Page 19

Diaphragm Seals

Seal effectively in
−65 to 500 F temperatures

Diaphragm seals for aircraft, missiles and rockets, and industrial applications are fabricated from nylon, Dacron, and glass fiber, and coated with silicones and other elastomers. Seals convert fluid pressure to mechanical movement, and are nearly friction-free. They seal effectively at temperatures from −65 to 500 F, in a variety of fluids. Diaphragms have bore

dimensions to 12 in., convolutions to depths of 4 in., and thicknesses of 0.010, 0.013, and 0.018 in. **Stillman Rubber Co.**, 5811 Marilyn Ave., Culver City, Calif.

Circle 772 on Page 19

Paralleling Reactor

is rated at
1600 amp rms

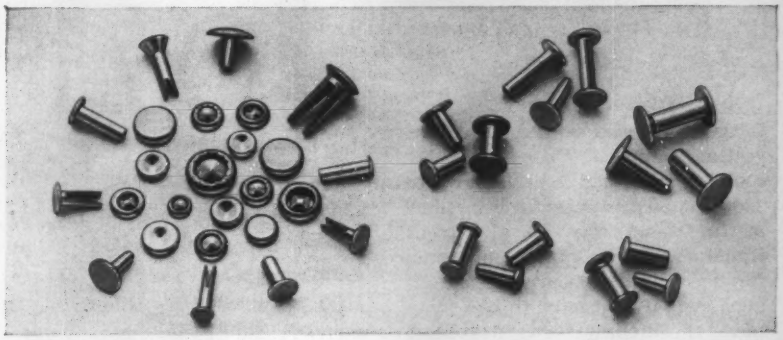
PR 1600 paralleling reactor is used to equalize current distribution to selenium stacks, germanium and silicon rectifiers operated in parallel, variable transformers, adjustable reactors, and rheostats. Unit is rated at 1600 amp rms for 50-C

Fastener Facts

by Henry Peterson, Chief Engineer — Judson L. Thomson Mfg. Co.

DESIGN PRODUCTION & PURCHASING DATA

HOW TO MAKE BOTH ENDS NEAT



Is This Your Problem?

When both ends of a fastener can be seen and touched, it's often a problem to design an assembly that has neat lines and smooth surfaces.

Two Solutions:

The rivets pictured above show two popular means of making both ends neat. The most common way is to clinch the rivet inside a cap that looks like the head. The greater bearing surface provided by the caps prevents rivets from tearing loose and also strengthens materials. The other method is to use compression rivets, consisting of accurately matched pairs of solid and deep-drilled rivets that give a secure pressed fit.

1. Rivets Plus Caps

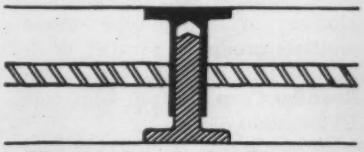
Thomson Standard Caps are made of steel and brass in diameters ranging from ¼" to 9/16" with flat or concave backs. They can be finished or japan-colored to match the self-piercing Thomson Deep-Drilled or Bifurcated (Split) Rivets of your choice.

Clinch strength with caps depends on your choice of rivet. The scored clinch of deep-drilled rivets is much stronger than the two-legged clinch of split rivets of the same diameter.

Thomson Caps are applied by a two-hopper machine that automatically feeds and sets all standard sizes of Thomson Deep-Drilled and Split Rivets and their matching caps. Hand-fed machines are also available.

Thomson Machines, in both bench and floor models, can be had to meet your special requirements.

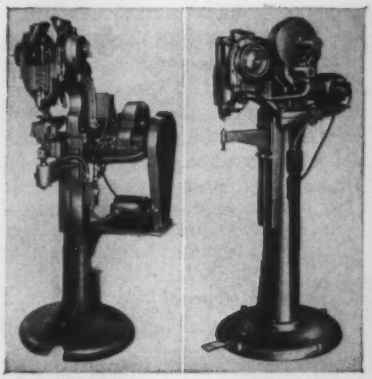
2. Compression Rivets



Thomson Compression Rivets come in precision-made male and female pairs. Each pair consists of a solid rivet with chamfered shank and a deep-drilled rivet to match. Because their most common use is for attaching handles to knives, they are often called "Cutlery Rivets".

Thomson Compression Rivets — cold headed from aluminum, brass, nickel silver and steel — are designed to seat snugly in counterbored holes. So, they give a smooth, projectionless surface to the product or assembly. They also provide the strongest pressed fit in the rivet industry. Heads may be trimmed in a secondary operation when more critical tolerances are required.

You have a choice of Thomson Rivet-Setting Machines for applying Compression Rivets: Thomson Knife Handle Machine (Style 137A) or two standard Thomson Rivet-Setting Machines (Style 161) in tandem.



Style 137A Style 161

The Thomson Knife Handle Machine is a versatile special-purpose machine that inserts male and female rivets into assemblies in a single operation. It handles rivets with heads up to 3/16" diameter . . . and lengths up to 1". Its arm is adjustable for the various assembly thicknesses and rivets lengths within its capacity.

When two standard Thomson Rivet-Setting Machines are used, one inserts the deep-drilled rivet; the other sets the solid rivet into the mate's hollow shank.

Complete Line:

Whatever your fastening problem, there's a Thomson Rivet that will cut costs and speed assembly. More than 800 stocked standards and more than 8000 standards in print-form promise you the kind of service that saves time and money.

More than 250 styles of Thomson Rivet-Setting Machines also offer you the advantages of high production rates on your assembly lines. The machine of your choice is custom-tooled for your application and factory-tested on actual samples before shipment. Available on a purchase or lease basis.

Design and Engineering Service

Thomson analyzes your fastening problems and makes specific rivet and machine recommendations . . . at your request. When called in before designs are frozen, our engineers can help you design around standard rivets and machines that cut costs and speed assembly. Thomson also saves time and money on your current fastening jobs by giving you a choice of more than 800 standard rivet types and sizes. Submit sketches, prints or samples for recommendations and quotations.

Free "Fastener Fact File"

This authoritative manual on all phases of riveting is "must" reading for anybody responsible for specifying or buying low-cost fasteners. It covers rivet types, applications, materials, finishes and other factors that simplify selection of the right rivet machine for any job. For your free copy, write: Judson L. Thomson Mfg. Co., Dept. B, Waltham 54, Mass.

JTL JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.

(Advertisement)

...more torque per pound and per dollar!

Merkle-Korff Geared Motors

In geared motors it's torque that counts! Highest torque output at lowest cost to you is achieved by Merkle-Korff's combination of two operating principles:

1. Maximum gear reducer efficiency, the result of 45 year's design experience. Precision hobbed gearing, heat treated. No molded or stamped gearing. Sealed-in-oil housings.
2. Maximum horsepower output with minimum weight motors, uniquely engineered to produce startling torques equal to or in excess of full load torque.

Application engineering is Cost Reduction Engineering at Merkle-Korff. From our many basic models and thousands of variations, let us engineer an improved geared motor drive for you.

From .4 to 300 inch pounds at 800 to ½ RPM

Many other speeds and torques above and below this range are available.

Write for complete information

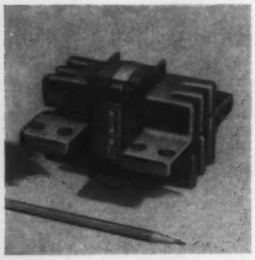
Representatives in principal cities

MERKLE-KORFF GEAR CO.

215 N. MORGAN ST., CHICAGO 7, ILL.
MOnroe 6-1900

Circle 544 on page 19

New Parts



temperature rise, with normal convection cooling. When forced-air cooled, rating can be increased to 2200 amp rms. Reactor functions in the same way as a current transformer with one-to-one ratio, forcing equality of current in windings, even if connected to two junctions of different forward voltage drop. It can be used to assure equal voltage distribution in paralleling of bridge-type circuits, multiple groups in parallel, or multiple strings in series. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 773 on Page 19

Teflon Electrical Tubing

in three wall thicknesses

Teflon electrical tubing in a complete range of sizes from AWG No. 30 through No. 0 is available in each of three wall thicknesses—thin, heavy, and nonstandard. Thicknesses range from 0.010 through 0.026 in. Temperature range is −400 to 500 F. Material has dielectric properties that are constant over a wide range of frequencies and temperatures. It is chemically inert to all chemicals and solvents except molten alkali metals and fluorine at elevated temperatures and pressures, has zero moisture absorption, extreme weather resistance, and complete absence of effects due to aging. **Dixon Corp.**, Bristol, R. I.

Circle 774 on Page 19

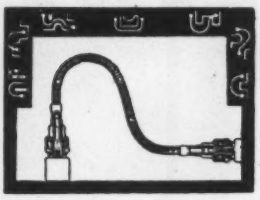
Engine

has weatherproof steel housing

K660G engine for industrial and agricultural applications is equipped with a weatherproof steel housing. Four-cycle, air-cooled unit has two opposed cylinders and develops 24 hp at 3200 rpm. Blower and hous-

FLEXIBLE SHAFTS

Handle wide variety of control applications.



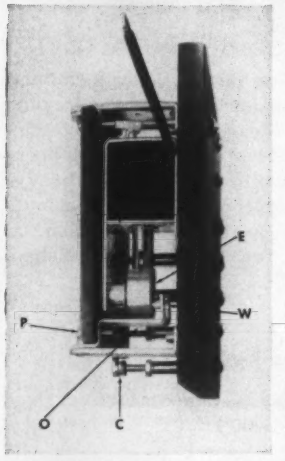
The Flexible Shaft today, although not complicated, is a specific component designed for specific applications. Industry in many fields, i.e., automotive, automation, aircraft, electronics, radio and television, machinery, and marine (to name but a few) have found flexible shafting to be more economical and yet more productive than whatever means they were employing to control motion from one unit to another where obstacles in the path of installation were impossible to do away with.

There are two types of flexible shafts. One is the power drive flexible shaft which utilizes a cable wound to rotate in one direction only. The outer layer of wire of the cable determines the direction rotation, and is wound so that the slack is taken up when the shaft is in operation, making it practically impossible for the cable to spring from its original shape. The other type is the remote control flexible shaft in which the cable is wound so that the slack is taken up no matter which direction the shaft is turned. The remote control shaft provides for both rotation and reciprocation, such as the opening and closing of a valve.

● ● ● For complete information as to how flexible shafting may help you solve your specific control problem, write F. W. Stewart Corporation, 4311-13 Ravenswood Ave., Chicago 13, Illinois.

Circle 545 on page 19

ASCO mechanically held relays are power driven in both directions with no dependency on springs or latches for operating or mechanically holding contacts

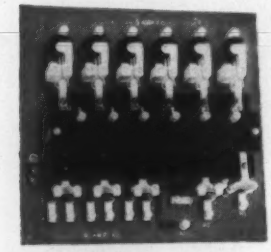


The Unique ASCO Mechanically Held Movement

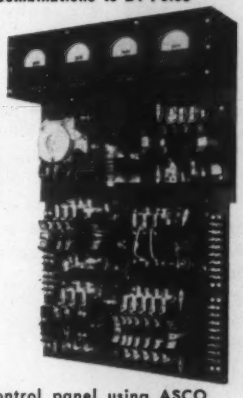
When the solenoid is energized, eccentric cam (E) is rotated. Weight drive pin (W) causes movement of operating lever (O). Lever (O) (connected to the contact finger block) rotates on pivot pin (P) and contacts such as (C) are opened or closed.

Note that with the solenoid de-energized, the entire mechanism is firmly locked in place by the angular position of the linkages—no springs, latches, or semi-permanent magnets are required!

ASCO Mechanically Held Relays A-C and D-C . . . to 25 Amperes Combinations to 24 Poles



Special ASCO Relay with 6 D-C Poles for 600 volts, 3 A-C Poles for 230 volts and 125 volts D-C control. Note Blow-outs on D-C Poles.



Control panel using ASCO Mechanically Held A-C Relays (Bulletin 1256-168). Notice multiple pole and double throw arrangements.

ASCO Power Driven Relays with No Springs or Latches:

- Provide higher contact pressures
- Minimize the possibility of contact welding
- Insure positive operation

Design simplicity is provided in ASCO Mechanically Held Relays through use of a single solenoid coil mechanism. The coil is momentarily energized during the instant of operation only. This momentary surge of power electrically operates the relay to *open and close* contacts; thus the relay is power driven in both directions, with no dependency on springs or gravity for operating and mechanically holding the contacts.

FEATURES

• No A-C hum or chatter • Operate in any position • Compact construction permits mounting on metal surfaces or panelboards • Operated by single-coil mechanism—positive in each direction • Silver contacts rigidly locked open or closed by angular relation of linkages—no delicate hooks or latches • Signal lamps require no extra contacts or control wires • Enclosed rating same as open rating due to liberal design and momentary mechanism without coil losses • All parts finished in cadmium plate or black to present good appearance and to match larger ASCO Switches.

APPLICATION

ASCO Mechanically Held Relays are used for automatic or remote control where A-C hum or chatter is objectionable, where coil loss is undesirable or where relays must not change position when the control circuit fails (low voltage release). ASCO Mechanically Held Relays are often used for master control of other control equipment, to prevent loss of voltage or control failure. These relays are frequently used for electric heaters, lighting, and similar applications.

Mechanically Held Relays are only part of the complete line of Relays made by ASCO. Our Catalog 57-S4 lists:

MAGNETICALLY HELD RELAYS
A-C or D-C . . . Normally Open . . . Normally Closed . . . Double Throw

ASCO Magnetically Held Relays use a physical arrangement which parallels that of ASCO Rocker Type Mechanically Held Relays. Since the two types are similar in appearance, they help to increase the attractiveness of control panels, at the same time offering interchangeability of contacts.

SPECIALIZED RELAYS

. . . Reverse Current
. . . Time Delay
. . . Brake Winding Time Delay
. . . Close Differential (Voltage and Current Types)
. . . Current Type, Welding
. . . Electronic
. . . Modified Arrangements

Write for your copy of "Relays by ASCO"—Catalog 57-S4.

Automatic Switch Co.

54-A Hanover Road, Florham Park, New Jersey
FRontier 7-4600

ASCO

Springs by the Millions

Accurate makes springs by the millions—many of our customers use a million a month. That takes a lot of spring know-how, experience and skill. But to produce precision springs in large quantities at nominal cost takes more than that. It takes imagination.

Imagination allows Accurate to approach problems without being too influenced by conventional methods. To successfully produce large quantities of precision springs Accurate customer service begins in the design and engineering stage. Highly developed skill in producing special tooling for large quantities often helps lower overall cost. Springs held to close tolerances are assured by rigid quality control and inspection. Packaging is designed to provide ease of handling and speed the customers' production. Scheduling and planning departments assure quantities delivered to meet your needs and reduce inventory requirements.

That is the type of experience, skill . . . and imagination, that allows Accurate to produce springs by the millions. Plan your springs with Accurate too.

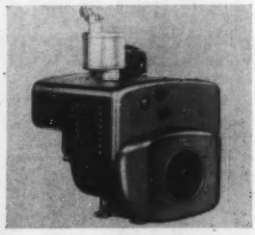
ACCURATE SPRING MANUFACTURING COMPANY

3824 W. Lake St., Chicago 24, Illinois

SPRINGS • WIRE FORMS • STAMPINGS

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

New Parts



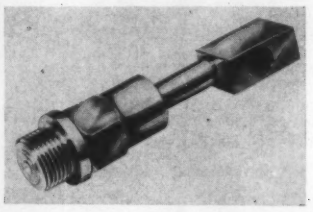
ing baffles direct a large volume of cooling air around finned cylinder and head area, assuring correct temperatures under all operating conditions. Unit has heavy-duty, rainproof, silencer-type muffler and gear-type lubrication. A 5½-gal fuel tank is furnished. **Kohler Co.**, Kohler, Wis.

Circle 775 on Page 19

Pressure Pickup

withstands temperatures above 5000 F

Water-cooled pressure transducer is for use in high-pressure, high-temperature applications. It withstands temperatures above 5000 F. Frequency response is flat to 10,000 cps. Exposed parts are stainless steel and resist oxidation under severe conditions. Transducer is immune to external vibration and is



flush-mounted. Unit is available for 0-1000 and 0-2000 psi ranges with 1 per cent of full scale accuracy. **Norwood Controls,** unit of Detroit Controls Corp., Norwood, Mass.

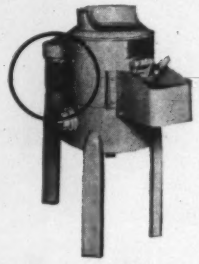
Circle 776 on Page 19

V-Belting

operates over small sheave diameters

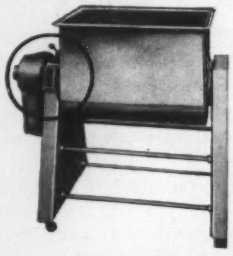
Thoro-Link V-belting is designed for use where conventional or endless-type V-belt cannot be installed or replaced without long machine downtime. Belting is extremely flexible and operates efficiently over small sheave diameters. Each

Townsend impact riveter protected by an Allen-Bradley Bulletin 600 starter.

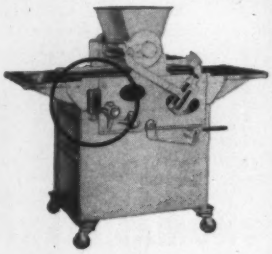


Gifford-Wood vegetable peeler with an Allen-Bradley Bulletin 600 starter.

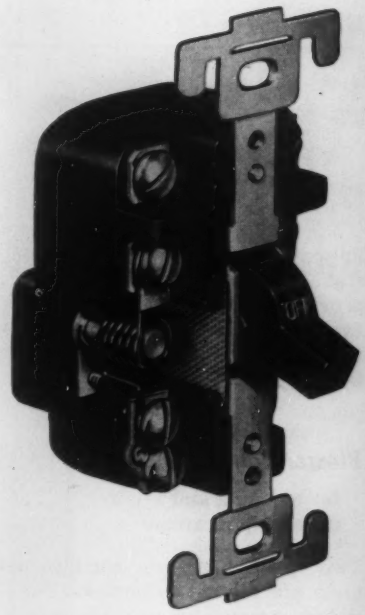
Unit space heater protected by an Allen-Bradley Bulletin 600 starter.



Kleen-Kut meat mixer has a ¾ hp motor and an A-B Bulletin 600 starter.



Triumph cookie dropper is protected by an Allen-Bradley Bulletin 600 starter.



LOW COST QUALITY MANUAL STARTERS
....for motors of 1 hp or less

Many small machine tools, restaurant equipment, fans and blowers, space heaters, etc., are operated by fractional horsepower motors. But even though the motors are small and relatively inexpensive, a motor burnout may disrupt important production schedules and, therefore, prove to be a costly accident.

Play safe—equip all of your small motor drives with Allen-Bradley Bulletin 600 starters. They have a built-in solder pot thermal overload breaker which remains accurate and dependable. It is low cost safety and production insurance.

Write for Bulletin 600, please.

Allen-Bradley Co.
1333 S. First Street
Milwaukee 4, Wis.

AB

In Canada—
Allen-Bradley Canada Ltd.
Galt, Ontario

ALLEN-BRADLEY
SOLENOID MOTOR CONTROL
QUALITY

Bulletin 600 starting switches fit into standard conduit boxes. They can be supplied in general-purpose, watertight, and explosion-proof enclosures for every service.

Circle 547 on page 19

SEEKING THE IDEAL MATERIAL FOR...

- Molds for powder metallurgy?

- Sintering boats?

- Crucibles, jigs, plates?
- Similar hot applications?

HERE'S YOUR ANSWER

Speer carbon and graphite parts are not wetted by molten metals. They hold their shape with no warping, regardless of temperature. They have high heat transfer and will not break down under severe thermal shocks...will not crack or split... are chemically inert.

Easily machined or fabricated, Speer carbon and graphite parts can be provided in almost any size and shape to your *exact* dimensional tolerances. If you have a design problem involving high temperatures, examine the advantages—and economies of Speer Carbon. Speer's knowledge and experience is yours for the asking—mail the coupon today for further details.

SPEER Carbon Co. St. Marys, Pa.

Please send information on carbon for use in

_____

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Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 548 on page 19

New Parts

link is prestretched under controlled tension. Reinforced rivets provide positive lock-fit. Belting is available in all sizes in both regular and oilproof construction. **Dayton Rubber Co.**, Dayton 1, Ohio.

Circle 777 on Page 19

Blower-Heater Units

for warming and drying applications

Two blower-heater combination units are for use in hot-food vending machines, photographic dryers, food warmers and other warming and drying applications. Coiled-wire heating element is well insulated to protect outer wall. Blower is designed for continuous operation; heater can be thermostatically controlled through separate terminals. Motor for both units op-

erates on 110 v, 60 cycle. Type DS (shown) delivers 55 cfm (free air) at 3000 rpm. Type YSS delivers 50 cfm (free air) at 1500 rpm. **Heinze Electric Co.**, 685 Lawrence St., Lowell, Mass.

Circle 778 on Page 19

Electrical Insulations

have purified asbestos base

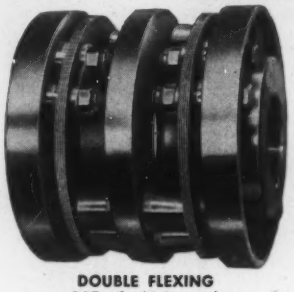
Types 71 and 72 Quinterra epoxy-saturated electrical insulations for Class B applications have a highly purified asbestos base which provides excellent electrical and thermal properties. Type 71 is a high resin content product with superior electrical properties. It is available in finished thicknesses of 4 and 5 mils, as tape, cut sheets,

FOR MAINTENANCE FREE POWER TRANSMISSION

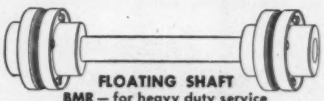
Specify

THOMAS

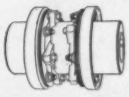
FLEXIBLE COUPLINGS



DOUBLE FLEXING
DBZ—for high speed, heavy duty drives



FLOATING SHAFT
BMR—for heavy duty service with excessive misalignment



DOUBLE FLEXING
AMR — for engine and medium speed drives

SINGLE FLEXING
SS — for engine-driven generator sets with out-board bearings

Thomas' 40 years of flexible coupling experience is at your disposal to help you meet ordinary applications or special variations for unusual cases.

UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES.

1 Freedom from Backlash Torsional Rigidity
2 Free End Float
3 Smooth Continuous Drive with Constant Rotational Velocity
4 Visual Inspection While in Operation
5 Original Balance for Life
6 No Lubrication
7 No Wearing Parts
8 No Maintenance

Write for Engineering Catalog 51-A

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U. S. A.

Circle 549 on page 19

Electrical boxes gang-punched and formed on one machine

This machine at Knight Electric Products Company, in New York, bangs out 24,000 of these square electrical boxes in an 8-hour day—punching the holes and dovetail tabs, cutting the knockouts and bending up the box all in one blow.

Time was when they punched and formed the boxes from coiled hot-rolled sheet, then galvanized them electrolytically. Then along came Bethcon, the product of Bethlehem's continuous galvanizing lines, to give Knight an already-galvanized coil with which to work. This eliminated the electrolytic cycle, and produced a box with a heavier zinc coating than would normally be obtained through electro-galvanizing.

The Knight people will agree that Bethcon has another important advantage for manufacturers: a much tighter and more uniform application of the zinc coating to the base steel. This means that Bethcon can take severe forming, drawing or bending without cracking the galvanizing.

There are all kinds of instances where Bethcon has helped manufacturers turn out new products or improve on old ones. Makers of such widely different products as air cooler cabinets, steel tubing, electrical raceways for cellular steel flooring—these and others are profiting from the strength, light weight and low cost made possible by the use of Bethcon.

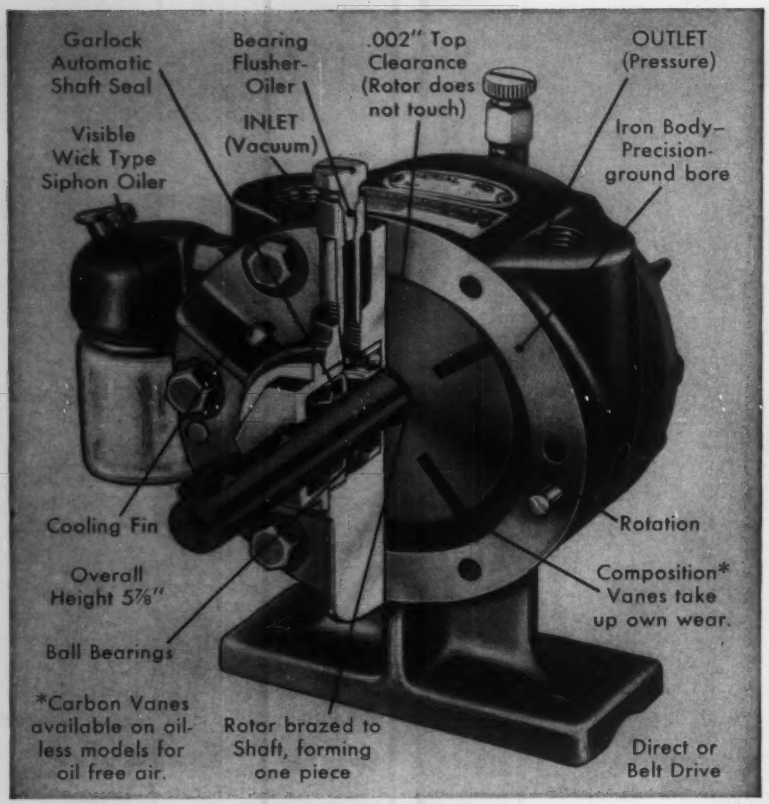
Where you need the strength of steel, tightly coated for corrosion-resistance, you're likely to find the answer in Bethcon sheet steel. One of our representatives will gladly discuss your problem with you.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

Circle 550 on page 19


Garlock Automatic Shaft Seal
Bearing Flusher-Oiler
.002" Top Clearance (Rotor does not touch)
OUTLET (Pressure)
INLET (Vacuum)
Visible Wick Type Siphon Oiler
Iron Body–Precision-ground bore
Cooling Fin
Rotation
Overall Height 5⅞"
Composition* Vanes take up own wear.
Ball Bearings
*Carbon Vanes available on oil-less models for oil free air.
Rotor brazed to Shaft, forming one piece
Direct or Belt Drive

rotary vane

Quality and simplicity keep GAST AIR PUMPS operating for years at high efficiency levels

INTEGRAL-MOTOR PUMPS 1/12 to 1/3 H.P. .6 to 4 CFM. to 28" VAC., to 25 PSI.

LIGHT-DUTY PUMPS, V-belt or direct drive. 2 to 24 CFM. Moderate vacuum or pressure.

HEAVY-DUTY PUMPS, 1/4 to 1-1/2 H.P. 4 to 21 CFM. To 28" VAC. or 30 PSI. Cooling fans and fins.

As original components—or for special plant use—Gast Air Pumps offer important advantages. This cutaway reveals many reasons why they are specified as "original equipment" by more and more leading manufacturers.

All models are built to high quality-precision standards in a new, modern plant. All embody this inherently efficient, simple rotary-vane design. Balanced rotor is free of vibration. Sliding vanes are light in weight—for minimum motion-energy-friction loss compared to other pump designs. As vanes take up their own wear automatically, pump delivers full performance through years of use.

Get full details—write for "*Application Ideas*" *Booklet and Catalog.* Many sizes—*mention capacity and type that interests you!* Gast Manufacturing Corp., P. O. Box 117-P, Benton Harbor, Michigan.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

Circle 551 on page 19

New Parts

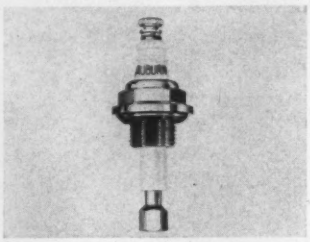
or rolls to 36 in. wide. Type 72 is a normal resin content product with good electrical properties. It is furnished in thicknesses of 3, 4, 6, and 9 mils, in tapes, cut sheets, and rolls to 36 in. wide. **Johns-Manville Corp.**, 22 E. 40th St., New York, N. Y.

Circle 779 on Page 19

Liquid Level Electrode

for high-pressure, high-temperature use

HP 10 liquid level control electrode, originally developed for use in removing water from helium gas, has laboratory and chemical processing applications. It is rated for pressures to 10,000 psi and temperatures to 700 F. Unit in-



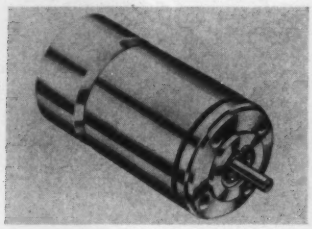
corporates glass-center electrode seal, captive copper compression gasket, stainless-steel shell, and 95 per cent aluminum-oxide insulator. Thread size is 18 x 1.5 mm pitch rolled. **Auburn Spark Plug Co. Inc.**, 126 York St., Auburn, N. Y.

Circle 780 on Page 19

Servomotor

operates at temperatures up to 200 C

Electromagnetic inertia - damped, size 11 servomotor has a rotor inertia of 1.3 gm per sq cm, torque at stall of 0.63 oz-in., and acceleration at stall of 34,200 rad per sec^2. Designed as the mechanical equivalent of an ac notching filter network, unit is inherently stable and insensitive to variations in carrier frequency. Power requirement for standard model is 4.0 w per phase. Fixed windings operate from a 115-v, 400-cycle source, and can be wound for any standard carrier voltage supply. Control windings can be custom wound for input from various impedances.



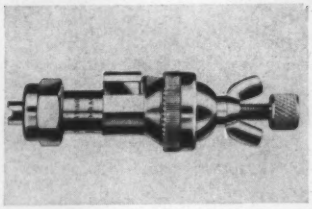
Servomotor is rated for continuous duty at stall with a maximum operating temperature of 200 C. **Helipot Corp.,** Div., Beckman Instruments Inc., Newport Beach, Calif.

Circle 781 on Page 19

Spray Nozzle

for manifold installations

Spray nozzle equipped with manually operated shut-off assembly is designed for manifold installations where selected nozzles must be independently shut off. Construction incorporates a diaphragm valve, shut-off screw and wing nut. Nozzle is brass with internal monel-metal strainer. Interchangeable



orifice tips are available for a wide capacity range. Full-cone, hollow-cone, and flat-spray patterns are also available. **Spraying Systems Co.,** 3201 Randolph St., Bellwood, Ill.

Circle 782 on Page 19

Binary Time-Code Generator

produces maximum of 128 binary-coded time signals

Datex Model DC-103 binary time-code generator is designed to produce a serial output of one synchronizing pulse followed by eight bits of binary coded dc timing signals per sec. Total number of unique binary coded time signals produced is 128. Time pulse generator is an electromechanical type, consisting of commutator switch and binary code disc driven by

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Other new Mars products include: the Mars-Pocket-Technico for field use, the Mars "Draftsman's" Pencil Sharpener with the adjustable point-length feature, and the efficient, clean Mars lead sharpener. All available — along with the established standards: Mars-Lumograph black graphite drafting pencils, Mars-Technico lead holder and leads, and Tradition-Aquarell painting pencils — at all leading engineering and drafting supply dealers.
J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

NEWS FROM FLEXONICS

BELLOWS APPLICATION ENGINEERING

One of a series of reports on more effective use of metallic bellows in new or unusual applications.

BELLOWS TYPE VACUUM VALVES

How Westinghouse uses Flexon Bellows in the vacuum system of Ignitron Rectifiers

The Ignitron Rectifier manufactured by Westinghouse Electric Corporation is an ingenious utilization of the rectifying property of the mercury vapor arc. This development has not only extended the scope of mercury arc rectifiers to the lower voltage range, but has provided new high standards of performance.

Maintenance of Vacuum Is Essential

It is essential that the Ignitron be substantially free from gases other than mercury vapor. Westinghouse provides the means of evacuating the tube with an integral vacuum system. Vacuum is maintained by a continuously operated mercury vapor vacuum pump capable of evacuating a vessel to the order of a fraction of a micron. The mercury vapor vacuum pump discharges to an interstage reservoir which in turn is exhausted by a rotary vacuum pump.

Two bellows type vacuum valves are used in the system. In both, Flexon stainless steel bellows are employed as shaft seals.

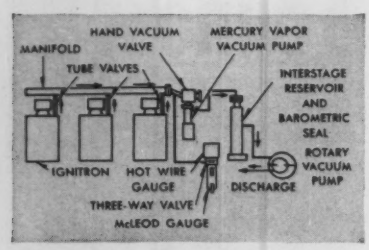


Fig. 1 Schematic view of vacuum system for Ignitron Rectifiers.

The Hand Operated Vacuum Valve

The bellows type vacuum valve is designed especially for use between the rectifier vacuum manifold and the mercury vapor vacuum pump. It consists of a machined steel bar, one end of which is made to form a vacuum gasket seat and also hold the movable mechanism of the valve. The other end of the valve body is drilled to form the valve intake. The outlet is a machined hole in the side of the valve body.

The bellows assembly consists of a stainless steel bellows welded to the bolted-on portion of the valve and also to a steel bar with flange at the lower end of the bellows. A rubber gasket is bolted in place to the flange end of the steel bar.

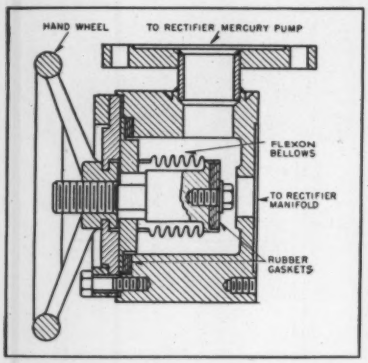


Fig. 2 Cross section view of the bellows type vacuum valve used between the rectifier and the pump.

The Three-Way Vacuum Gauge Valve

A three-way bellows type valve is employed in connections to the vacuum gauges. It is similar in design and construction to the valve used in the vacuum pump line except that it is provided with an additional port.

Valve Quality and Life Depends on Bellows

In devices such as these, the ability of the valves to hold the required vacuum level depends on the leak tightness of the bellows. The life of the valve depends on the bellows' resistance to fatigue developed in opening and closing the valves. In the face of these potential dangers, bellows quality and dependability are essential.

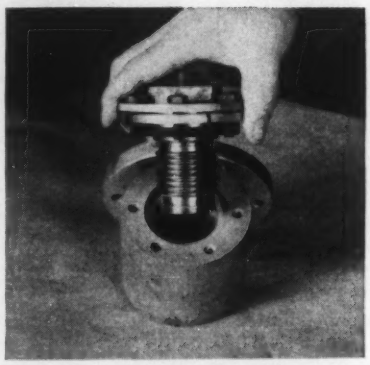


Fig. 3 Valve mechanism being lifted out of the valve body.

Why Flexon Bellows Are Used

Westinghouse uses Flexon Bellows Assemblies in the Ignitron Rectifiers to take advantage of Flexonics Corporation's facilities and bellows manufacturing know-how. Flexonics' application engineers are cost conscious, skilled in recommending the bellows or bellows assemblies that provide the performance required by the device at the lowest price consistent with these requirements.

Engineering Assistance

The Flexonics Application Engineering Staff will be pleased to assist you in your bellows application problems. For specific recommendations send an outline of your requirements. For your bellows reference file, write for the Flexon Bellows Design Guide.

Flexonics *Corporation* BELLOWS DIVISION

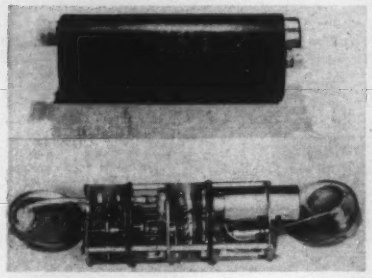
1339 S. THIRD AVENUE • MAYWOOD, ILLINOIS

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Also Manufacturers of Rubber and Metal Hose Assemblies • Expansion Joints • Aircraft Components

Circle 553 on page 19

self-contained 28-v dc motor. Unit operates in temperatures from −65 to 170 F. It resists shock of 30 g



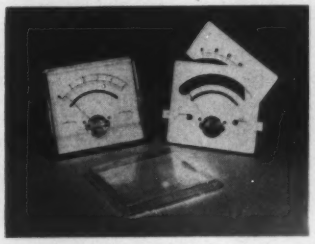
on any axis, and vibration of 15 g. **G. M. Giannini & Co. Inc.**, 918 E. Green St., Pasadena 1, Calif.

Circle 783 on Page 19

Custom Meters

have interchangeable range scales

Rectangular 2½, 3½, and 4½-in. custom meters have interchangeable scale faces. Shunting and multiplier resistors permit coverage of more than 100 ac and dc voltage and current ranges. Meters incorporate D-Arsonval moving-coil design, fatigue-tested springs, and



stress-relieved assembled units, accurate within 2 per cent. Six meters cover a variety of ac and dc ranges. **Precise Development Corp.**, Oceanside, N. Y.

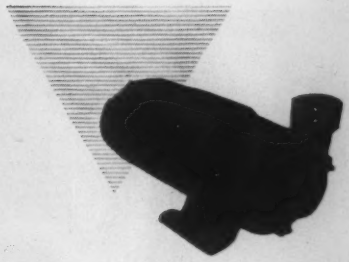
Circle 784 on Page 19

Flexible Shafts

in six models

Flexible shafts, complete with couplings, simplify many problems relating to power drive, remote control or internal coupling of machine movements. Available in six models, they were developed primarily for small-quantity requirements for design, experimental and prototype work. Three shafts are

(*Please turn to Page* 238)



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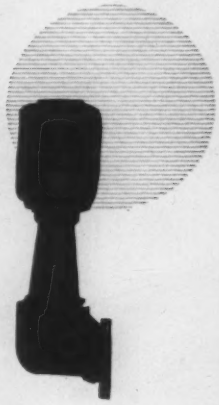
with I-R motorpumps



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Motorpumps are available for sidewall, immersion or foot mounting. Get complete information now by writing for descriptive literature.

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Circle 554 on page 19

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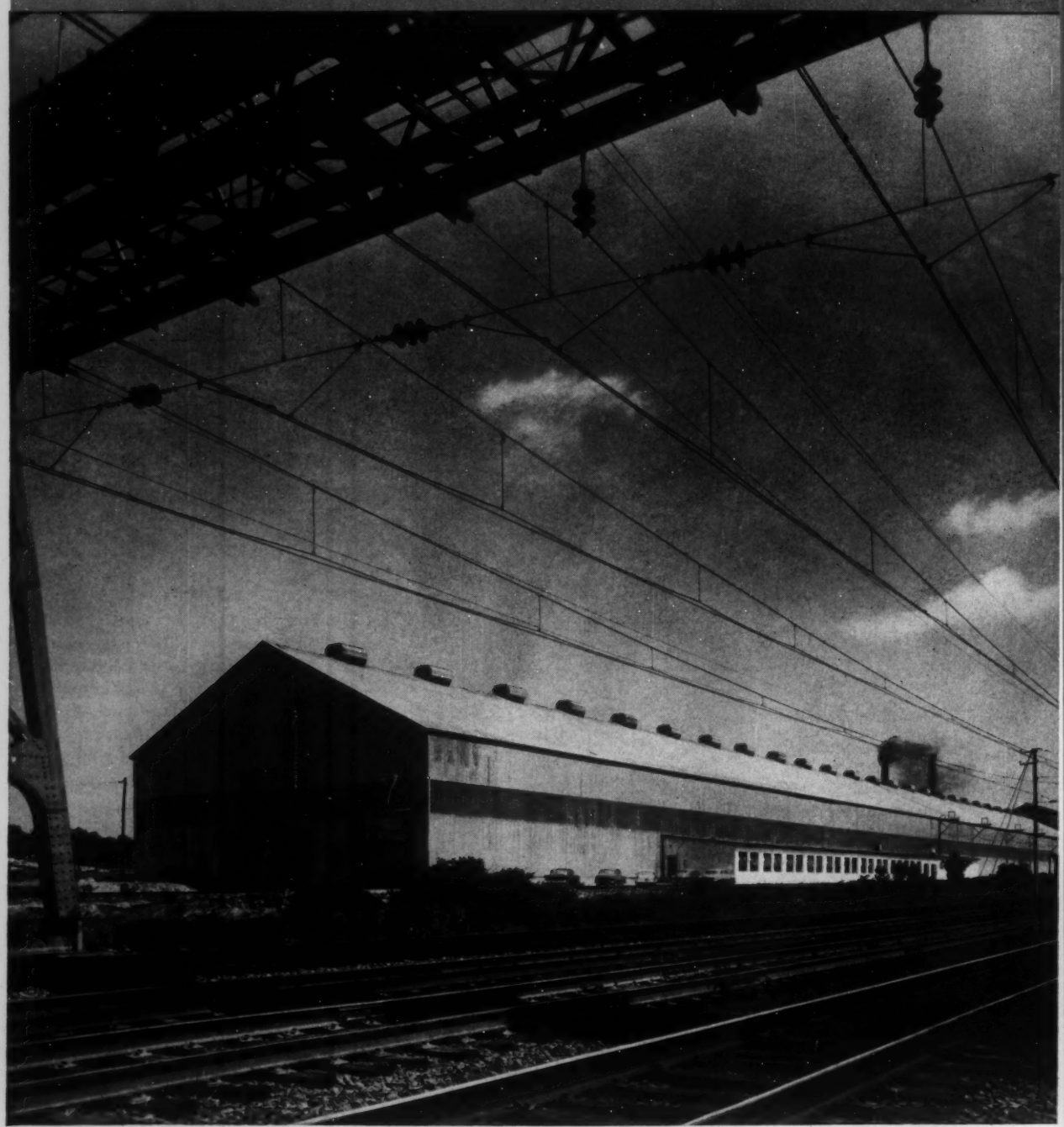

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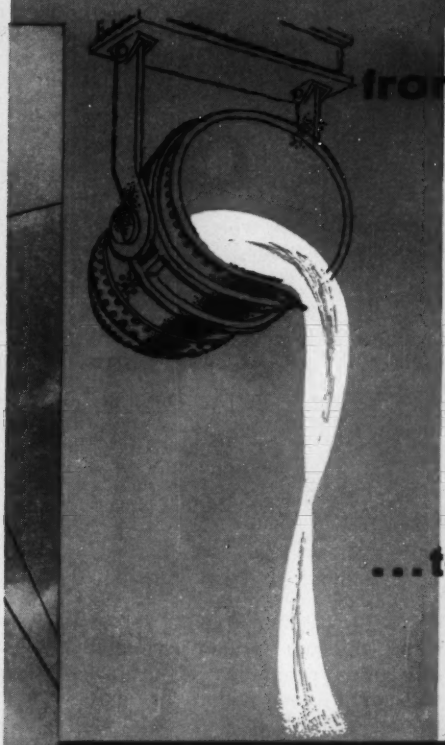

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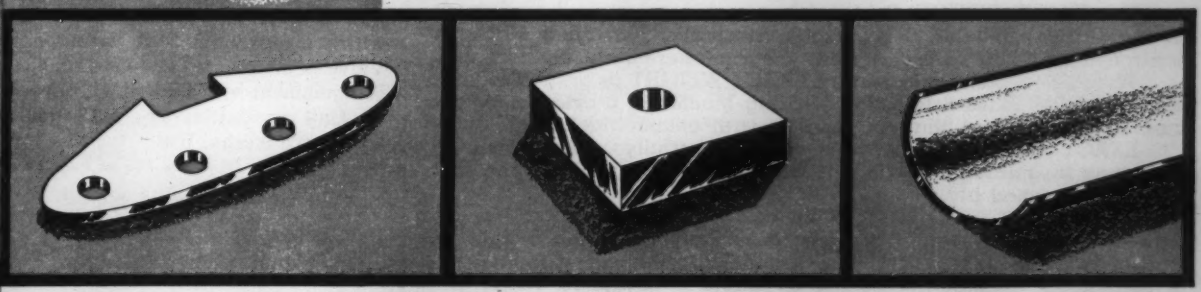

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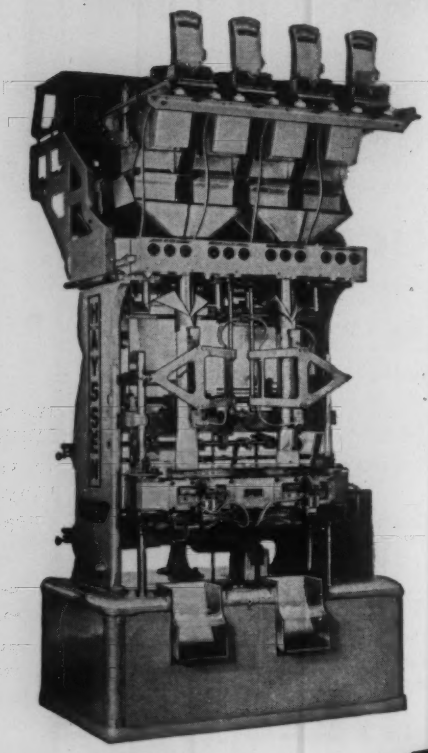
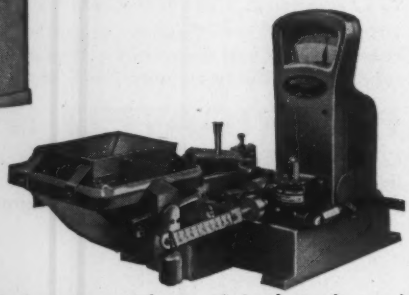
5497

ONE MORE EXAMPLE of how EXACT WEIGHT Scales are being used in modern machinery design



Model 610
Net Weigher*

EXACT WEIGHT SCALES CONTROL ACCURACY IN HAYSSEN PACKAGING MACHINE



The EXACT WEIGHT Scales, incorporated as original equipment in the Hayssen Model "F" Compak Automatic Packaging Machine, control each filling operation with accuracy heretofore unattainable.

Weigh Feeders, developed by EXACT WEIGHT as original equipment for HPM Plastics Injection Molding Machines, provide more accurate measurement than is possible with columetric feed.

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EXACT WEIGHT Scales can be easily incorporated into the design of any machine that requires accurately controlled weight as part of its function.

Complete engineering data is available to designers. Write, giving your specific application.

*The Net Weigher, shown above, is designed for original equipment installation. Write for complete details.

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Exact Weight SCALES

BETTER QUALITY CONTROL . . . BETTER COST CONTROL

Circle 556 on page 19

New Parts

(*Continued from Page* 235)

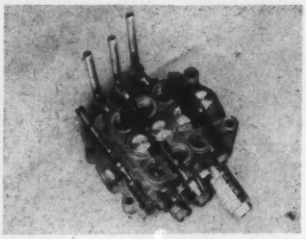
for remote-control applications, and three for power drive. Each shaft is stocked in 3-ft lengths. Inner shaft elements are high-grade wire, with neoprene casing. Balanced construction on remote-control models assures minimum backlash with approximately equal strength in either direction of rotation. **S. S. White Industrial Div.,** 10 E. 40th St., New York, N. Y.

Circle 785 on Page 19

Hydraulic Control Valve

is adaptable to wide application range

Series 3200 hydraulic control valve has a capacity of 35 gpm. It is available with one to six plungers, in completely balanced design,



with plungers sealed at each end. Four positions of control, with or without detent, are provided. Positive pilot-operated relief valve permits setting valve to within a maximum 50-lb variation. Valve is adaptable to a wide range of equipment application. **Hydraulic Unit Specialties Co.,** P.O. Box 257-N, Waukesha, Wis.

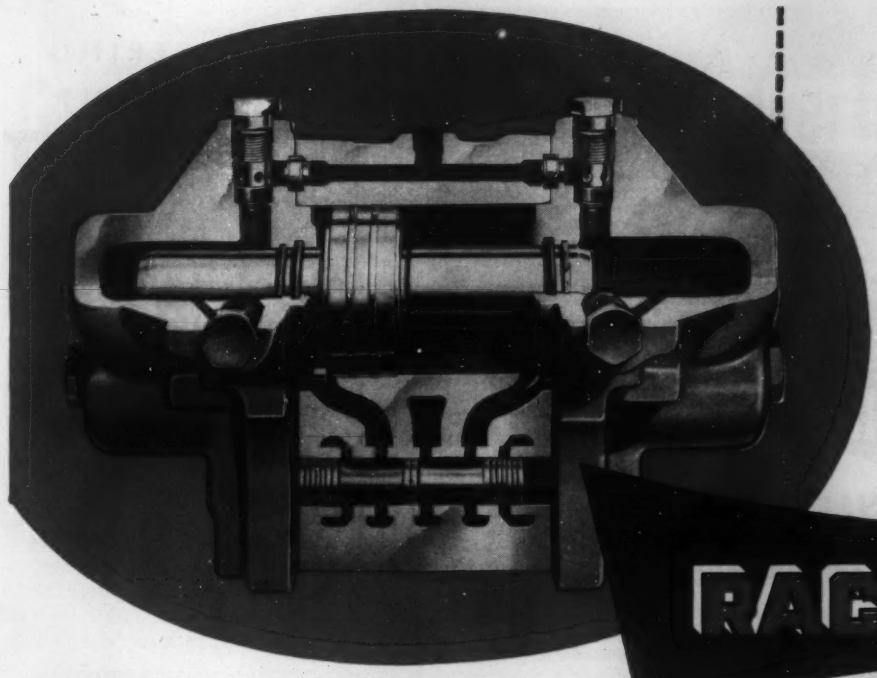
Circle 786 on Page 19

Caster Wheel

resists high impact and is nonmarking

Atlasite molded-rubber composition truck-caster wheel eliminates marking or smudging of floors. Caster wheel has high impact strength and carries heavy loads. Quiet in action, it wears gradually without wearing out or damaging floors. Wheel is suitable for all applications except those involving high temperatures and use of some acids. **Bassick Co.,** 3045 Fairfield Ave., Bridgeport 5, Conn.

Circle 787 on Page 19



RACINE®

HYDRAULIC PRESSURE BOOSTERS

HIGH PRESSURE VALUES— AT LOW PRESSURE COSTS

This patented RACINE PRESSURE BOOSTER builds pressures as high as 5000 psi. With it you can economically multiply the pressure from your low pressure pump as much as seven to one

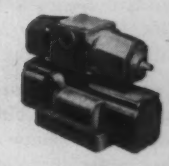
It allows you to use low pressure at low cost for many operating and closing actions. High pressures to 5000 psi, automatically cut in for final forming and holding operations, or curing cycles on your machine.

Simple design, pressure lubricated, rugged parts and the use of extremely high tensile materials make RACINE Pressure Boosters practically indestructible They last for *years and years* with little maintenance or repair.

If you need pressures to 5000 psi, write us now. Learn how you can have "High Pressure Values at Low Pressure Costs."

OTHER RACINE HYDRAULIC PRODUCTS

MODEL Q
Variable Volume
Vane Type
Hydraulic Pump



4-WAY VALVE
Twin Solenoid
Pilot Operated

FLUID MOTOR
Vane Type
50 to 3500 rpm
Pressures to 1500 psi

RESERVOIR
With Control Panel
Designed to your space
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RACINE

NFPA NATIONAL FLUID POWER ASSOCIATION

RACINE HYDRAULICS & MACHINERY, INC.
2073 Albert Street
RACINE, WISCONSIN, U. S. A.

Circle 557 on page 19

GASOLINE
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VACUUM
OIL
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TYPE OF APPLICATION
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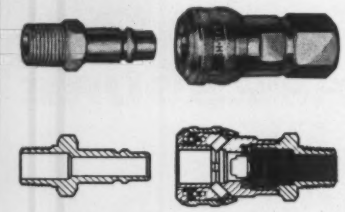
QUICK-CONNECTIVE COUPLINGS

For Pneumatic or Hydraulic Line Circuits

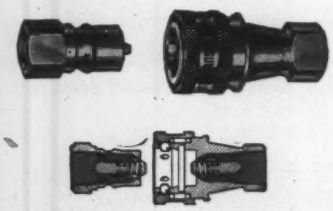
Regardless of whether your particular application requires One-Way Shut-Off, Two-Way Shut-Off or Straight-Through Couplings—or couplings for special service on fluid lines carrying oxygen, acetylene, steam, etc.—you can always select a Hansen Coupling specifically engineered for your requirements.

As the result of years of experience with fluid line circuits on many different types of manufactured units, all Hansen Couplings are carefully designed to incorporate the specific features needed for the job they are intended to do.

The next time you are planning to design a fluid line circuit, make use of the know-how of your nearest Hansen representative. You'll find him a real help in getting exactly the couplings you need to do the job.



ONE-WAY SHUT-OFF



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STRAIGHT-THROUGH COUPLING

Write for the Hansen Catalog

Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes and types of Hansen Quick-Connective Couplings. Write for your copy.

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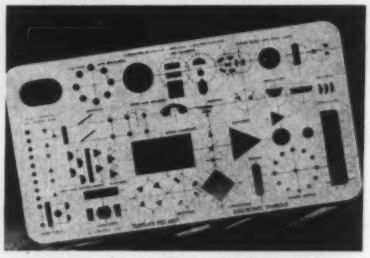
ENGINEERING DEPARTMENT
EQUIPMENT

Electronic-Symbol Template

covers MIL-STD-15A and ASA.Y32.2 specs

Broad-range schematic diagrammer for electronic circuitry work offers symbols for pnp and npn transistors, diodes, electronic tubes, power plugs, pilot lamps, relays, phone jacks, connectors, rotary switches, resistors, capacitors, inductors, transformers, amplifiers, and blocks. It covers MIL-STD-15A and ASA.Y32.2 specifications. Applications include use



in television and radio, electric control work, power layouts, electrical-appliance design, communications, military and commercial instrumentation, and electronics. Template is of dimensionally stable matte-finished vinylite, printed in matte inks. **A. Lawrence Karp,** 16 Putnam Park, Greenwich, Conn.

Circle 788 on Page 19

Drafting Board Attachment

keeps large drawings smooth and taut

Rollo-Draft attachment for drafting boards, which operates on the same principle as a roll-film camera, keeps drawings of any size smooth and taut. It eliminates splicing sections together for blueprinting. Unit consists of two tubes, one of which holds fresh drafting or tracing paper. As each section of a drawing is finished, it feeds onto the second roll mounted at the opposite side of the board. Paper can be moved right or left

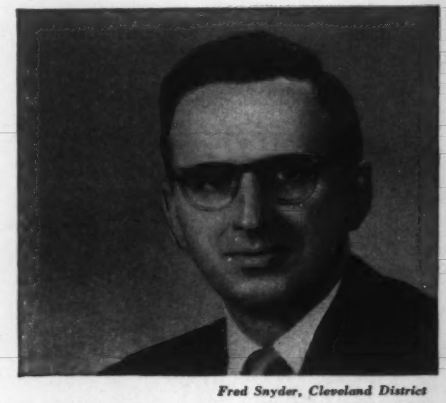
Can specialized business publication advertising actually sell?

By reputation, salesmen are reluctant to credit anything but their own selling efforts for getting names on the dotted line.

Actually, it's quite a different story. The most successful salesmen will tell you two important things about selling. 1. That the selling process is largely a matter of communicating ideas. 2. And that specialized business publication advertising can help importantly to register information with prospects.

Of course each salesman will express this in his own way . . . but they all agree that selling would be far more difficult without the advertising that appears in the industrial, trade and professional publications that serve the specialized markets to which they sell.

Here, for instance, is what a salesman has to say about this kind of advertising:



Fred Snyder, Cleveland District
Worthington Corporation

sells to industry

Says Mr. Snyder:

"We have, of course, sales leads from our business paper advertising that are forwarded to us on a monthly basis. But also the trade advertising has its impact on many who do not at the time request specific information. Worthington is far better known today than it was five years ago, due in no small measure to the aggressiveness of its advertising and sales promotion department.

"Their work makes my job easier. First of all, we have an entree in companies where some Worthington products were not previously as well-known as our original line. We're getting a lot better sales coverage on all products. The Corporation manufactures so many products today that even regular customers may be unfamiliar with some of these products. Through trade advertising and sales promotion we have been able to sell the whole Worthington line.

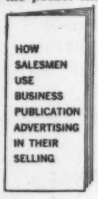
"Getting back to sales leads—they are particularly helpful to our dealers. In Cleveland, W. M. Patterson Supply will undoubtedly receive inquiries from Worthington's advertising. Scott-Tarbell, Inc., Cleveland Oak Belting, or other dealers handling special product lines will pick up leads from our advertising to help them get business.

"I think we've grown eightfold since the war. This year we hit two hundred million. It used to be that twenty-five million was a good year. The advertising and sales promotion department has aggressively been attacking their part of the problem within the last five years. Prior to that the name Worthington was not nearly so well-known and we put much less emphasis on advertising."

Ask your own salesmen what your company's business publication advertising does for them. If their answers are generally favorable you can be sure that your business publication advertising is really helping them sell. If too many answers are negative it could well pay you to review your advertising objectives—and to make sure the publications that carry your advertising are read by the men who must be sold.

How salesmen use their companies' advertising to get more business

Here's a useful and effective package of ideas for the sales manager, advertising manager or agency man who would like to get more horsepower out of his advertising. Send for a free copy of the pocket size booklet entitled, "How Salesmen Use Advertising in Their Selling," which reports the successful methods employed by eleven salesmen who tell how they get more value out of their companies' advertising.



You'll find represented many interesting variations in how they do this. Some are very ingenious; all are effective. You can be sure that more of your salesmen will use your advertising after they read how others get business through these simple methods.

The coupon is for your convenience in sending for your free copy. Then, if you decide you want to provide your salesmen with additional copies, they are available from NBP Headquarters in Washington, at twenty-five cents each. Or, if you choose you can reprint the material yourself and distribute it as widely as you please. But first, send for your free copy.

NATIONAL BUSINESS PUBLICATIONS, INC.
Department 2E
1413 K Street, N. W.
Washington 5, D. C. STerling 3-7533

Please send me a free copy of the NBP booklet "How Salesmen Use Advertising in Their Selling."

Name _____

Title _____

Company _____

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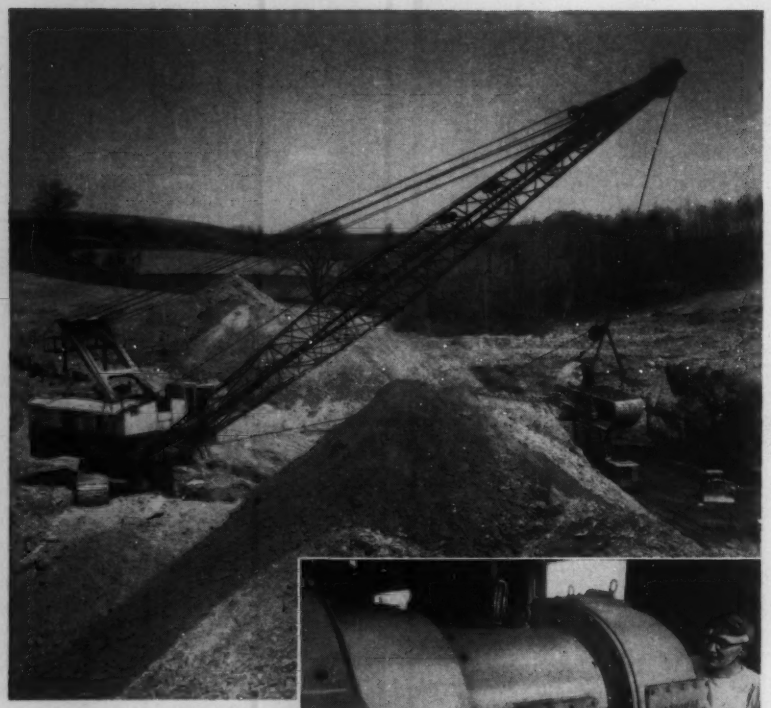
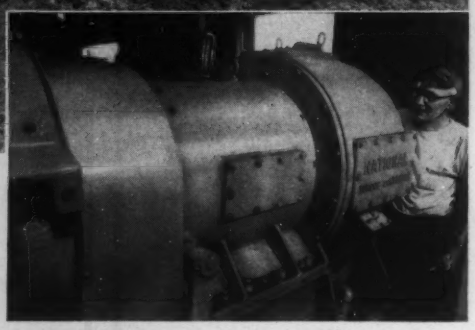
National Business Publications, Inc.

NBP

. . . each of which serves a specialized market in a specific industry, trade or profession.

Circle 559 on page 19





NATIONAL TORQUE CONVERTER

helps to "MUSCLE UP" this hard-working MARION Drag-line

Every working day, this Marion drag line moves hundreds of tons of rock and earth overburden at the Ferris Coal Company mine, East Palestine, Ohio.

A National Torque Converter helps to maintain this tough production schedule and also to ease the punishment on both operator and machine. The converter automatically delivers the power needed for the individual operation, increasing it when resistance is encountered, decreasing it when resistance is eased. Loads that would stall a direct-connected engine automatically get the greatest response from the converter. And all shocks and strains are absorbed, making the operator's job easier, and helping to reduce repair and maintenance on the equipment.

If you have any heavy machine with a power supply of from 100 to 1000 hp, where loads vary and operation is "stop and go," you will find a National Torque Converter an easy way to increase production and lower maintenance. For additional information, just write:

THE NATIONAL SUPPLY COMPANY

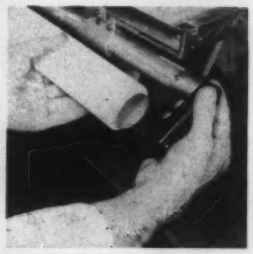
INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.

Pace-setters in the progress of industrial power transmission

Circle 560 on page 19

Engineering Equipment



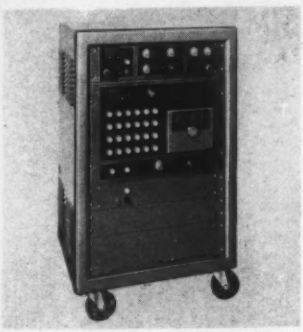
by means of cranks on either side, and then locked in position. **Aqua Sportsman Inc.**, 2518 Leslie Ave., Norwood, Cincinnati 12, Ohio.

Circle 789 on Page 19

Spectrum Analyzer

for frequency range of 0.5 to 20,000 cps

Any complex electrical waveform can be analyzed continuously within its frequency range by this spectrum analyzer. It presents a readout showing frequencies included in the waveform and amplitudes of each of the frequency components. Waveforms can be continuous or discontinuous. Analysis is performed over successive 10-sec periods. Readout is a bar graph



produced by a pen-writing galvanometer showing a frequency spectrum. Units are available on special order for frequency ranges other than 0.5 to 20,000 cps. **Edin Co. Inc.**, 207 Main St., Worcester 8, Mass.

Circle 790 on Page 19

Pocket-Sized Computer

for adding and subtracting

Fractomator computer counts up to 100,000.00 in decimal amounts, and permits addition and subtraction of dimensions expressed in

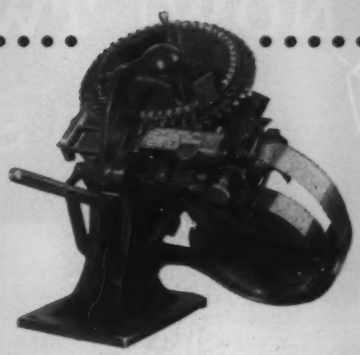
WANT TO SOLVE A METAL LABELING PROBLEM?

Here's how to make METAL* LABELS on-the-spot - in seconds!

"MIDGIE"
Portable Hand Embosser 5/32" Type Size

SINGLE-LINE MANUALLY OPERATED BENCH MODELS
Offered in a wide variety of type sizes & styles. From 1/8" to 1".

MODELS AA BB CC



MULTIPLE-LINE MANUALLY OPERATED BENCH MODELS
1/8" & 3/16" Type Sizes

MODEL ML
FOR EMBOSSING
ONE TO FIVE LINES OF
1/8" OR 3/16" TYPE
ON STRIP OR PLATES

In the Lab... In the Field... In the Shop...

WHAT IS YOUR LABELING PROBLEM?

pattern numbers	storage crates	chemicals
plating	motors	storm windows
parts bins	lots-in-process	electrical parts
tools	instruments	stock shelves
machinery	shipments	plants & shrubs
dyeing vats	heat treating	cables
animal tags	dip tanks	heat equipment
wiring	badges	all-weather equipment

* Aluminum, Brass, Copper, Carbon Steel, Stainless Steel, Nickel, Monel, Zinc, Colored Metals & Many Others.

WE MANUFACTURE a complete line of manual and power-operated Metal Embossing *Machinery* for making single-line and up to 10-line, Metal Labels, inclusive.

IF YOU WANT Embossed Metal *Tags*, we supply them to order. Write for details, prices.

METAL EMBOSSING MACHINERY MANUFACTURERS SINCE 1883 ROOVERS – LOTSCH CORPORATION Formerly ROOVERS BROS., INC.

For the solution to your metal labeling problem
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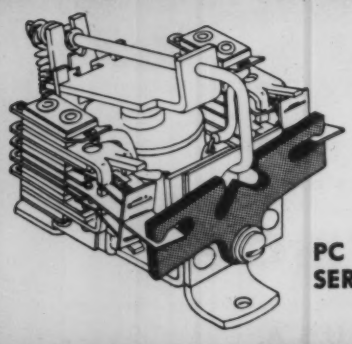
ROOVERS-LOTSCH

CORPORATION Dept. "M"
3611-14th Ave. BROOKLYN 18, N. Y. U. S. A.

NOW! TWO-COIL PERFORMANCE AT SINGLE COIL COST!



PC SERIES

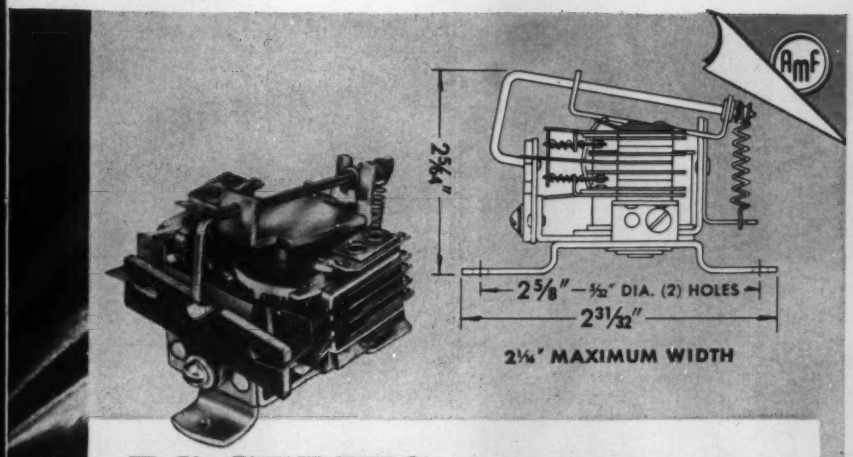
This new series, the PC, is an ingenious impulse latching relay which employs a single coil and armature to activate an insulated rocker arm. Switching is positive, fast (30 milliseconds).

Its low cost, dependability and versatility make it ideal for a wide range of uses. For example, two leading TV set manufacturers use the PC in their remote control circuits as an "off-on" switch. It is also used by a maker of automatic garage doors. Conveying systems, automatic processing equipment, flow controls—the PC is right for these applications and many more.

Contact arrangements are available up to 4 Form C (4PDT), and the snap-action contacts are rated 5 amps. at 115 V. AC resistive. The relay may be ordered open, as shown, or in a metal dust cover.

Write or wire today for complete information.

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA / SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY



PC SERIES ENGINEERING DATA

GENERAL: Description: Single coil, impulse latching relay.
Insulating Material: Laminated Phenolic.
Insulation Resistance: 1500 megs. min.
Breakdown Voltage: 500 V. RMS.
Ambient Temperature: —55° C. to +85° C.
Weight: 5 ozs. (open)
Pull-In: DC, 75% / AC, 78% } for nominal voltage.
Operate: 30 MS.
Terminals: Pierced Solder Lugs
Coil: Two #20 AWG Wires
Contacts: One #20 AWG Wire
Enclosures: "A" Can.

CONTACTS: Arrangements: 4 Form C. max. (4PDT)
Material: ⅛" dia. Silver Cadmium oxide gold flashed.
Load: 5 amp. @ 115 V. AC resistive.
Pressure: 20 grms. min.

COIL: Resistance: .016 to 34,500 max.
Power: DC, 9 watts. / AC, 18.4 Volt Amps. } at nominal voltage.
Duty: Intermittant.
Insulation: Cellulose acetate wrap; varnish impregnated (open).

MOUNTINGS: Two 13/32" dia. holes on 2⅝" center.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

Potter & Brumfield, inc.

PRINCETON, INDIANA
SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N.H.

Mail the coupon below for further engineering data on P&B's new PC Series relays *plus* new compact catalog of standard type relays. If you need answers to a specific application problem, write in detail.

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. USMC (Ret.)
Special Projects Engineer

Please send me complete data on the new PC Series relays, plus the new compact catalog of P&B standard relays.

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See our catalog in Sweet's Product Design File

Circle 562 on page 19

feet, inches, and fractions, including in sixteenths. Converting is performed automatically by machine. Subtraction is performed on the reverse side of the unit, and the same operating technique as for addition is employed. Result can

be read on either side of machine. Unit is furnished with a variety of stands, and in pocket models. **Alexander Drafting Equipment Co.**, 423 S. Chester Ave., Dept. 123, Pasadena, Calif.

Circle 791 on Page 19

Differential Amplifier

amplifies low-level signals

Model DA-101 wide-band differential amplifier handles low-level signals, including pulse signals, without noise or hum pickup. Noise is 6 mu v referred to input with bandwidth of 50 kc at 3 db point and at 20,000 ohms differential input impedance. Gain is adjustable in steps from 100 to 2000X, with

gain accuracy of 0.1 per cent. Linearity is ±0.05 per cent. **Epsco Inc.**, 588 Commonwealth Ave., Boston 15, Mass.

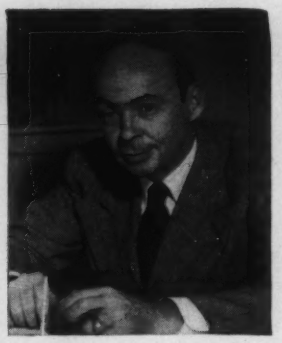
Circle 792 on Page 19

Ratiometer

for use with dc analog computers

Unity ratiometer provides fast, accurate readout and continuous balance. Unit has unlimited applica-

MICRO-BEARING ABSTRACTS



by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.

BEARING FITS AND FITTING PRACTICES

As shown in *Fig. 1*, the fitting of Micro-Bearings, like the fitting of larger ball bearings, chiefly involves the clearances between the inside diameter of the housing and the outside diameter of the bearing; the bore of the bearing and the shaft diameter.

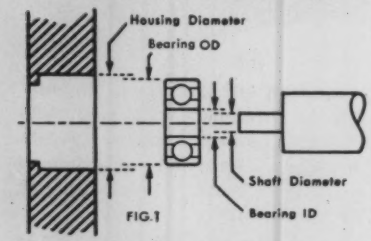


FIG.1

The achievement of the desired fit by dimensioning is illustrated in *Fig. 2*. The bearing ID is represented by the top blocks and the shaft OD is represented by the lower blocks. Such a block diagram could also be applied to housings and bearing outside diameters. In this block diagram, it will be noted, the bearing ID is represented by a .00015 tolerance with a similar tolerance for the shaft. A resulting fit of line to line to .0003 loose is shown.

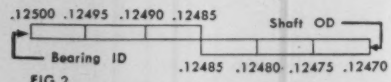


FIG.2

An interference fit not tighter than line to line is suggested for the following reasons:

1. *Difficulty in assembly.*
2. *Difficulty in disassembly. This is often more hazardous than the assembly operation and may result in total bearing destruction.*
3. *Reduction in radial play.*
4. *Danger of bearing ring conforming to possible poor geometry of mating shaft or housing.*

TOLERANCE DISTRIBUTION

The maximum .0003 loose condition shown in *Fig. 2* may be excessive in some applications. The fitting problem then resolves itself to reducing this extreme, and yet maintain the maximum tight fit of line to line. The looseness may be reduced by redimensioning the shaft to .12490/.12475 as shown in the block diagram, *Fig. 3*.

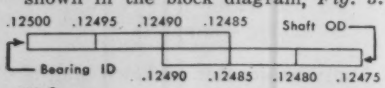


FIG.3

If the frequency distributions of shaft and bearing ID sizes were statistically normal, the modal fit of all parts would be 0.0001 loose. Accordingly, an insignificant percentage of parts would be mated to the extreme values, and for practical purposes could be ignored.

With regard to bearings' outside diameters and bores, however, normality of the distribution curve cannot be assumed. During the grinding operation, the "most metal tendency" tends to skew the frequency distributions for bearing ID's and OD's in the direction of most metal.

In grinding and finishing shafts and housings, similarly skewed distributions occur.

Operating on a modified probability distribution of tolerance is possible if the volume of parts is sizeable. But the approximate distribution of shaft and housing sizes must be verified if this method is to be used.

MATERIALS and SURFACE FINISHES

The ease of assembly is also affected by materials and finishes. The following factors must be considered:

1. *The galling characteristics, hardness and ductility of the materials involved.*
2. *Finish lay patterns produced by various tools and techniques used.*
3. *R M S surface finish values achieved.*
4. *Geometry of shafts and housings as regards out-of-roundness, taper, etc.*

The possible combinations of these elements in any single application are so numerous that their gross effect can only be ascertained by trial and error, or by a detailed study of operations on individual applications. A more complete discussion of fitting practices, including sizing methods and coding, is found in our design handbook.

DESIGNERS HANDBOOK FREE TO ENGINEERS

If you work with miniature bearings, you'll find this new, 70 page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

It will be sent free to engineers, draftsmen and purchasing agents. Write to:

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

Engineering Equipment

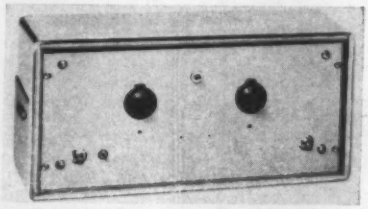
tion with dc analog computers, and is designed for ease of operation and simplicity of readout. Automatic polarity indicator gives an average of 1½ sec per reading, with high accuracy. Output shaft extension has many uses, including mounting of shaft encoders, output potentiometers, and other rotary transmitting devices. It is scaled ten revolutions full scale with output torque of 5 oz-in. Model UV-100 has accuracy of 0.05 per cent full scale; Model RV-1 has accuracy of 0.1 per cent full scale. **Servonics Inc.**, 834 N. Henry St., Alexandria, Va.

Circle 793 on Page 19

Differential Analyzer

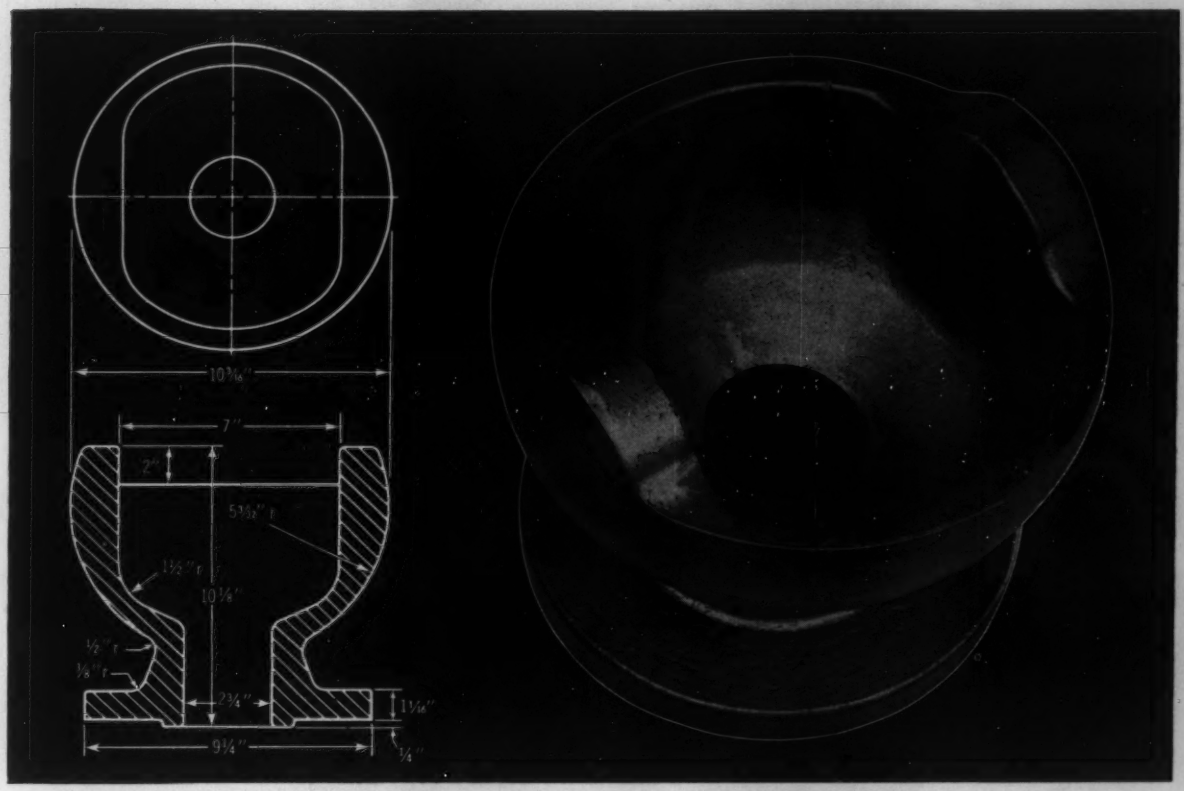
separates groups of pulses of varying amplitudes

Model 695 single-channel differential analyzer, for use in scintillation spectrometry, proportional counting and similar applications, is a differential pulse-height analyzer for separating groups of pulses of varying amplitudes. Instrument passes on to the output only those pulses whose peaks fall between two predetermined amplitude levels. Input signal con-



sists of positive pulses from 0 to 100 v. Rise time is 0.2 mu sec; resolving time is 0.5 mu sec. Output signal consists of output pulses of 0 to 15 v negative for both differential and integral. Rise time is 0.4 mu sec. **Victoreen Instrument Co.**, 5806 Hough Ave., Cleveland 3, Ohio.

Circle 794 on Page 19



Forging stops service failures while saving 12½ lbs. of metal

A steel casting of a universal ball-joint housing had proved unsatisfactory for the Pettibone Mulliken Corp. It presented a serious service problem in the Speed Swing Loader line of this leading manufacturer of earth moving equipment. Even an increase in the size of this important component in the planetary axle assembly failed to give it the strength needed to hold up satisfactorily under unusual field conditions.

Commercial engineers proved that the housing with its unusual shape and characteristics—flanged on one end, belled on the other, and open on both ends—could be formed as an upset forging. The housings are now being produced by Commercial Shearing and Stamping on an 8-inch upsetter from 4½-inch round bar stock by the internal displacement method.

Since the switch to a forged unit by Pettibone Mulliken, there have been no rejects or failures due to faults in the metal. "Commercial forgings have held up so well under the toughest of applications, that we are now incorporating them in all planetary axle assemblies on our entire loader line", says Pettibone Mulliken.

And because the forging needs less metal for the required strength, Pettibone Mulliken has also been able to reduce the size of its housing section from 77 pounds to 64½ pounds per unit. Additional savings in both metal and final machining are effected because each housing—including a 2¾-inch pierced-through hole which was formerly machined—is forged close to final tolerances.

Whatever the size or design of a formed component, "print" to part forging like this is standard procedure at Commercial. A blueprint, sketch or sample of your component part is all Commercial engineers need. In their hands it could mean the right answer to *your* forming problem.

Inquiries for forming engineering assistance always welcomed. Address The Commercial Shearing and Stamping Company, Dept. S-42, Youngstown 1, Ohio.

SPECIALISTS IN CUSTOM FORMING THROUGH UPSET FORGING • STAMPING • HYDROSPINNING

COMMERCIAL shearing and stamping

Circle 564 on page 19

Breeching fabricated complete by Littleford Bros. Inc., for Ohio Edison Co., Akron

BIG SCALE fabricating at LITTLEFORD

Littleford fabricates all metals in almost any size. Why not use Littleford's 175,000 square feet of modern fabricating facilities, 300 skilled craftsmen and 75 years experience to assure quality fabricating for your individual needs? Send blueprints for prompt estimates. No obligation, naturally. Littleford Bros., Inc., dept. LB 260—424 E. Pearl St., Cincinnati 2, Ohio.

Circle 565 on page 19

Why leading manufacturers are "SWITCHING" WITH DENISON

LOXSWITCH

HEAVY DUTY LIMIT SWITCHES

- Longest mechanical life
- Soundest electrical circuit
- Water-, oil-, and dust-tight switches with metal or plastic covers
- Choice of 21 circuits
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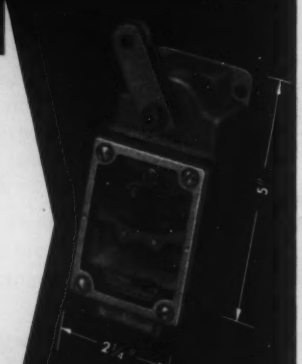
- Lowest Prices

Write for complete details today



LOXSWITCH is a registered trade mark for limit switches—pronounced lock-switch.

R. B. DENISON MFG. COMPANY
102 ST. CLAIR AVE. N.W. • CLEVELAND 13, OHIO

Specializing Exclusively in the Manufacture of Limit Switches

Stress Relief

RESEARCH being a subject of high current interest, it was inevitable that J. P. Henderson would have some worth-while comment. Here he discloses "a method of providing a research organization for many companies at no extra expense — except laundry bills," or

Have You Been Measured For Your White Coat?

Several months ago I had lunch with the head of a large research organization who was scheduled to address a group of businessmen that evening after dinner.

"I suppose," said I, "you are going to give them a big sales talk on research—its blessings and benefits."

"On the contrary," said he, "I am going to do just the opposite. I am going to talk it down, advise caution and investigation before launching into a research program."

I told him that he amazed me. Here he was—supposed to be selling research—and taking such a negative tack. What would his board of directors think of that?

"It's all right," he replied. "We don't have to sell research—magazines, newspapers, everybody does it for us. The average executive, making anything from buttons to oil cans, is sure that if he were to set up a research organization he could increase his profits, reduce his costs and probably come up with a supplementary product that would just naturally relieve him of all worries. There are a great many small and medium-sized companies whose product and organization setups are such that research can prove a false god. I preach caution."

Well, I listened to all of that and stored it away mentally. I recalled it when visiting an engineering friend in the East several weeks ago.

He looked downcast. "J. P.," he

said, "I'm worried. My boss is research-minded. He thinks he wants a research organization—he wants me to put some of my engineers on research.

"I get from him one of those typical presidential treatments. Mild but barbed criticism for not having produced the fruits of research over the past years but a complete blank look when I talk about personnel, budgets, and an initial and thorough study as to the purpose of such research and the form it should take.

"He implies I should use some of my present overworked staff, and to me that is ridiculous. Assign development jobs to men like that and the results are always meager. A project is started, then another job comes up that involves routine business, a rush order or something. You know what happens: the man drops his project because the current business can't wait.

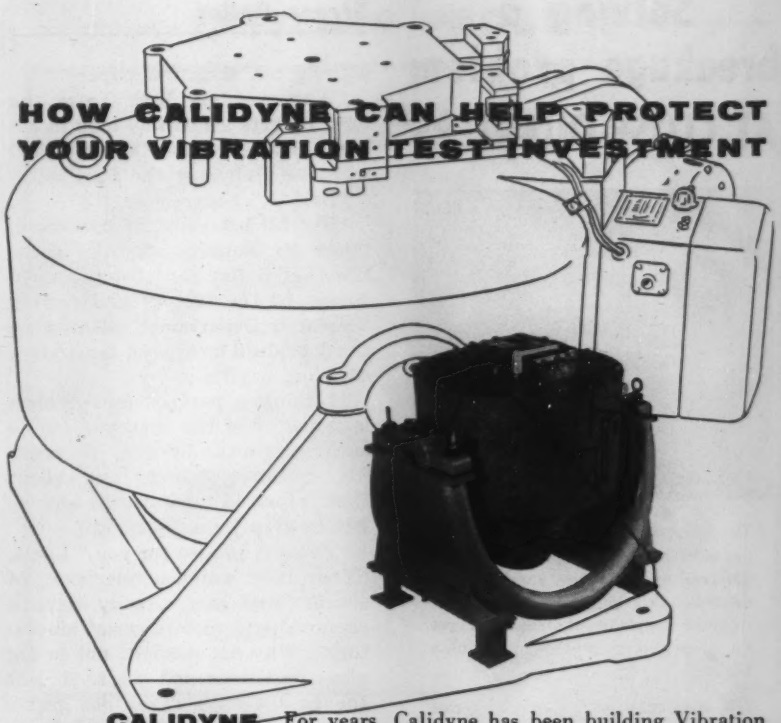
"If I were given a large sum for research I wouldn't know where to spend it, frankly.

"Don't look at me like that," he said. "Of course I could put more money to good use in my engineering organization. But you know the vast variety of our production. Where would product development pay off best? Or where would it be a flop? I think a lot of initial investigation is especially necessary in our case.

"You notice that I talk about 'product development.' The boss talks about 'research.' We would both have the same end in mind, regardless of what it's called.

"One of the things that gripes me is to hear the words 'pure research' bandied around in that group. I've seen the 'pure research' label applied to work that is pure bunk. To my mind *pure* research is study for study's sake without too definite an aim. If the knowledge gained is not yet useful but is nevertheless a contribution to science—such research is also a success.

"But I've heard businessmen talk about their laboratories and the purity of some of their staff. Their men were really working on product development. How long would they last if they came up with



HOW CALIDYNE CAN HELP PROTECT YOUR VIBRATION TEST INVESTMENT

CALIDYNE SYSTEMS ARE CUSTOM BUILT

For years, Calidyne has been building Vibration Test Systems to meet specific military, aircraft, automotive and industrial requirements. Most Systems have been custom-constructed for special applications. Although they were representative of the most modern equipment available at the time, it may now be to your advantage to modernize to meet the newer requirements of this fast-moving field.

HOW TO OUTWIT OBSOLESCENCE

Some of the older Calidyne Vibration Test Systems may have become obsolete to a point where they cannot be revamped to meet more modern requirements. With others, it is possible for us to up-grade the equipment so that its performance will compare favorably with any now being offered. In many cases this can be done without serious sacrifice of the original investment.

IT MAY PAY TO INVESTIGATE

When you want to investigate the possibility of bringing your Calidyne Vibration Test System up to date, get in touch with us here at Calidyne — we can quickly tell you what can be done. The telephone number is Winchester (Boston) 6-3810, or write:

THE CALIDYNE COMPANY

120 CROSS STREET, WINCHESTER, MASSACHUSETTS

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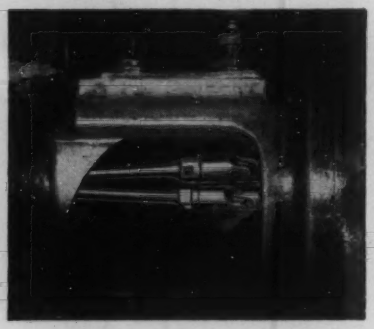
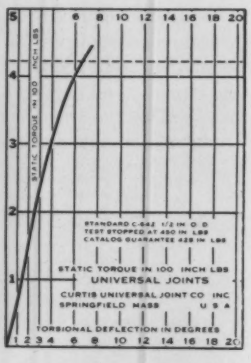
Circle 567 on page 19

Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.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Circle 568 on page 19

Stress Relief

nothing but scientific papers?

"Whenever my boss hears the term he gets a faraway look in his eyes. Probably like Cortez looked when he first saw the Pacific."

"Balboa," I corrected.

"But I'll bet you," he continued, "that six months after he spent the first dollar for cleaning up a corner of the factory and having 'Research Department' painted on the door, he'd be around demanding startling results.

"I think a part of my problem is a matter of the boss wanting to keep up with the Joneses. He hears his executive friends talk about their research laboratories and he has to keep jealously quiet."

"I've got an idea for you," I said. "Your boss watches television, of course. And you already have a chemical and metallurgical laboratory. Why not move it, put in big glass partitions and see to it that the boss always takes his guests past the lab on plant trips? Paint 'Authorized Personnel Only' on the door, put everyone in white coats and have a large microscope in prominent view.

"Then when his friends go by with questioning looks he can just give them a pleased look and say 'Hush.' Isn't that as far into research as he honestly wants to go?"

—J. P. HENDERSON

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Recent Books

Calculus Refresher for Technical Men. *By A. Albert Klaf; 431 pages, 5½ by 8 in., paperbound; published by and available from Dover Publications Inc., 920 Broadway, New York 10, N. Y.; $2.00 per copy.*

This book examines the most important aspects of differential and integral calculus in terms of 756 questions most likely to occur to the reader. The first major section covers differential calculus, including constants, variables, functions, derivatives, and logarithms, and the second major section covers integration, areas and volumes, successive and partial integration, and double integration.

A 50-page section illustrates practical applications of calculus to problems in mechanics, electricity, and other fields of engineering.

Trigonometry Refresher for Technical Men. *By A. Albert Klaf; 629 pages, 5½ by 8 in., paperbound; published by and available from Dover Publications Inc., 920 Broadway, New York 10, N. Y.; $2.00 per copy.*

This book presents various aspects of trigonometry by means of specially selected questions and detailed answers.

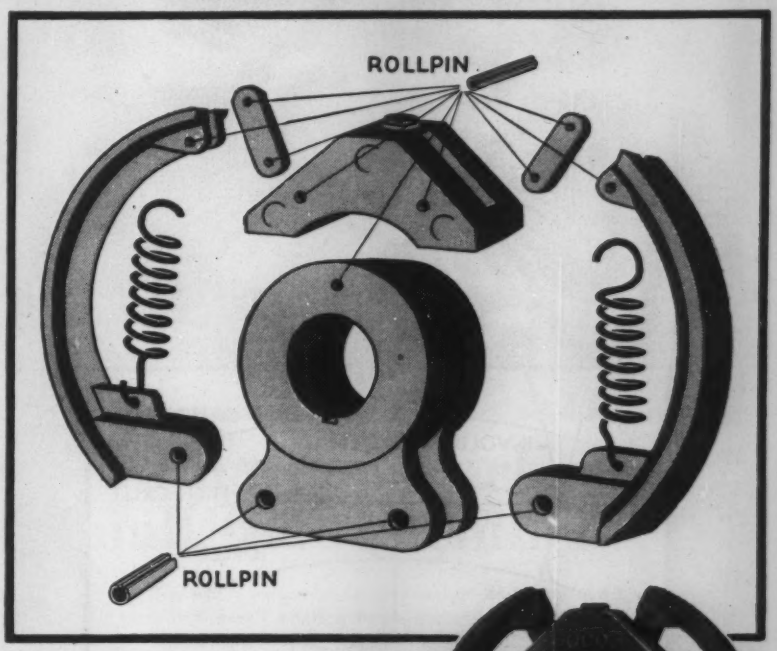
Major topics include angles, quadrants, trig functions, graphical representation, interpolation, equations, solution of triangles, and slide-rule use.

Time-saving methods of numerical calculations and simplification of angle functions are included.

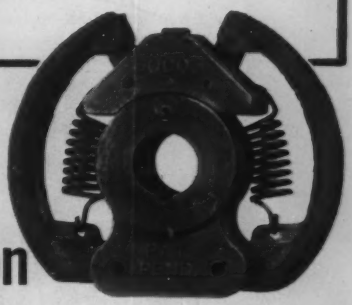
Analytical Design of Linear Feedback Controls. *By G. C. Newton, L. A. Gould, and J. F. Kaiser, all of M.I.T.; 419 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$12.00 postpaid.*

This book contains a comprehensive discussion of analytical de-

FASTENER PROBLEM



Rollpin use eliminates reaming operation



When the Lombard Governor Corporation engineers designed a new centrifugal clutch for Lombard chain saws, they faced a fastening problem: What fastener would provide simple, inexpensive assembly operations yet be strong enough and dependably secure under rugged service conditions?

Rollpin was the answer. A hollow, slotted spring type pin, oversize in relation to standard production-drilled holes, it is readily pressed into position, automatically locking itself in place through pressure on the hole walls. Lombard found that use of Rollpins eliminated a reaming operation—effecting an important saving in production costs—and performed without failure in the field.

Removal and re-use is easy, too. Rollpins can be easily driven out with a punch, and hammered back in again with equal ease. Unlike rivets, they require no secondary locking operation, and their heat-treated spring action provides extended re-usability.

If you use taper pins, set screws, rivets, hinge pins or any other pin type fastener, consider redesigning with Rollpin for simplified assembly operations at lower cost.

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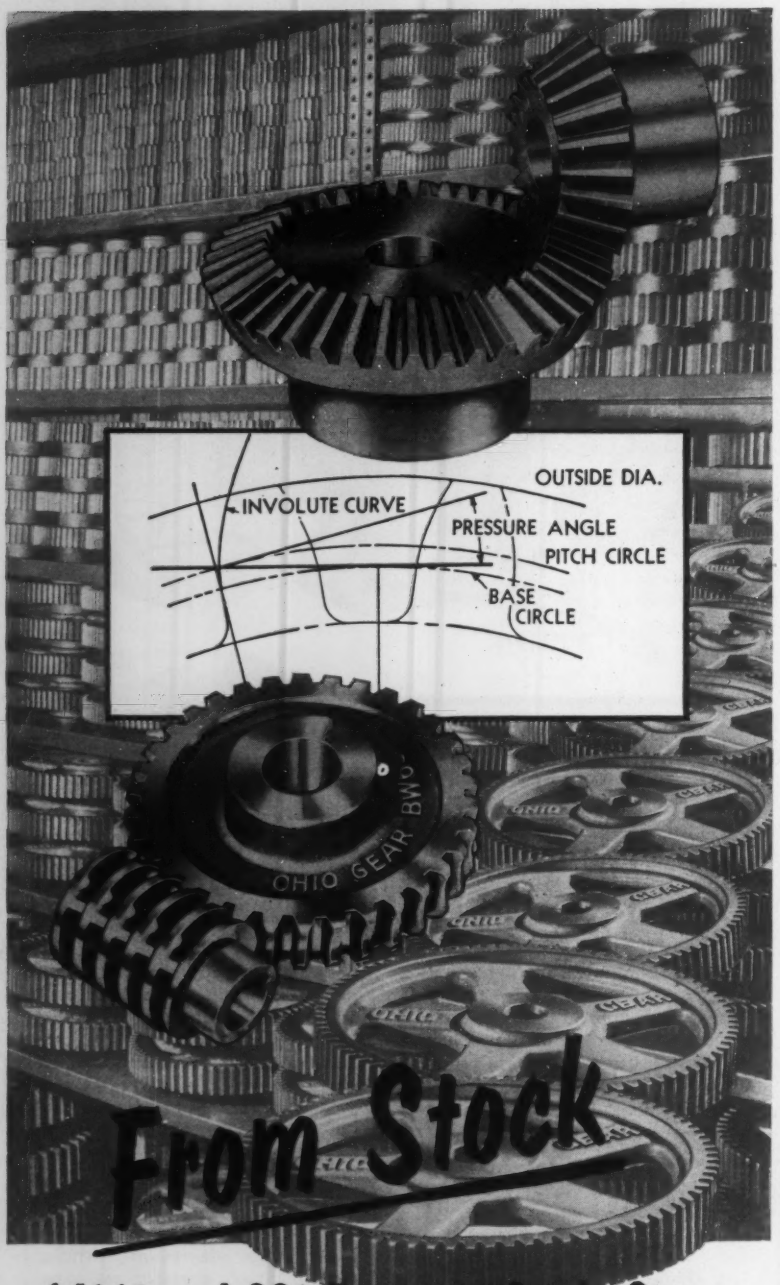
☐ Elastic Stop® Nut Bulletin
☐ Here is a drawing of our product. What fastener would you suggest?

Name_____ Title_____
Firm_____
Street_____
City_____ Zone____ State____

Circle 569 on page 19



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sign procedure for linear feedback controls along two performance indexes. One performance index, the integral-square error, is for systems subject to transient input signals, and the other, the mean-square error, is for stochastic input signals.

The analytical design approach described here provides a means of knowing whether or not performance specifications can be met. Designers proceed directly from problem specifications to compensations which minimize or maximize specified performance index.

Centrifugal and Axial Flow Pumps. *By A. J. Stepanoff, Ingersoll-Rand Co., 462 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, $12.00 *postpaid.*

This second edition presents new material on theory, design, and application of centrifugal and axial flow pumps. Expanded coverage includes centrifugal-jet pump systems, shut-off head for axial and mixed flow impeller pumps, principles of suction pump design, new viscosity correction charts, characteristics of mixed flow and axial pumps, and thermal cavitation criterion.

Also included are selected topics from hydraulics, speed and design constants, leakage, thrust, mechanical losses, and problems of design and applications.

Numerical Analysis. *By Kaiser S. Kunz, Ridgefield Research Laboratory; 381 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, $8.00 *postpaid.*

The purpose of this book is to develop a fundamental understanding of finite difference methods used in numerical solutions of problems in applied mathematics.

Included are studies of numerical solutions of algebraic equations, methods of interpolation, numerical integration, application of finite differences to partial differential equations, and numerical solution of integral equations.

A considerable portion of the

Circle 570 on page 19

book is devoted to finite difference tables and notation. Solutions of simultaneous linear equations and multivariate interpolation are treated extensively.

Association Publications

A Bibliography of Fluid Power. *8½ by 11 in., paperbound; available from the National Fluid Power Association, 1618 Orrington Ave., Evanston, Ill.;* $2.00 *per copy.*

This bibliography was compiled by the education committee of the National Fluid Power Association and represents a cross-section of literature available on fluid power. Only books have been included but, at a later date, a bibliography of articles and papers will be issued.

Three major sections of the book are devoted to hydraulics, pneumatics, and a combination of both. Books are listed alphabetically by title under subdivisions of these sections according to basic theory, data and tables, and applications. Included are date of publication of the book, price, number of pages, number of illustrations, charts, and tables; a brief summary of the book, and table of contents. An alphabetical author-title index is also included.

Standards are Everybody's Business. 101 *pages, 8½ by 11 in., paperbound; published by and available from American Standards Association Inc., 70 East 45th St., New York 17, N. Y.;* $4.00 *per copy.*

This book contains proceedings of the Seventh National Conference on Standards held in New York, October, 1956. Contents include chemical industry standards, screw thread standardization, safety standards, clarification and interrelation of steel specifications, standards for boilers and pressure vessels, and standardization in the atomic industry.

Creep and Recovery. 372 *pages, 6 by 9 in., clothbound; published by and available from the American Society for Metals, Cleveland, O.;* $6.00 *per copy.*

This book contains 14 papers presented at the Seminar on Creep

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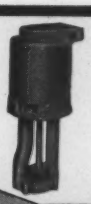

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Circle 572 on page 19

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and Recovery held in Cleveland in 1956.

Three major sections cover various aspects of recovery, interactions of dislocations and grain boundary behavior, and creep of crystalline nonmetals.

SAE Aeronautical Drafting Manual, 7th Edition. *17 sections, 8½ by 11 in.; available from the Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.; $5.00 per copy unbound, $7.00 bound.*

This revised edition is a complete rearrangement of the former manual plus numerous additions. Recommended practices are applicable to fields outside the aviation industry.

Major sections include: Preparation of drawings, decimal system, symbols, threads, gears, splines, special finishes, springs, welding, fasteners, and bearings.

Cast Metals Handbook. *By Gustav Lieby; translated from the German edition; 316 pages, 8½ by 11 in., clothbound; available from American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.; $10.00 per copy; AFS members, $7.00 per copy.*

This book contains information of use to designers in selecting materials best suited to specific casting problems.

Major sections include properties of cast metals, designing for casting, estimation of casting costs, index of equivalent ferrous and nonferrous casting alloy specifications, significance of mechanical tests, and molding methods.

Specific materials treated are gray and white cast irons, malleable cast iron, and nonferrous alloys.

Professional Engineers' Income and Salary Survey, 1956. *40 pages, 6 by 9 in., paperbound; available from the National Society of Professional Engineers, 2029 K St. N. W., Washington 6, D. C., 50 cents per copy to NSPE members, $1.00 per copy to nonmembers.*

This report represents findings of the third national salary survey conducted by the National Society of Professional Engineers. The present survey compares data with

previous surveys and shows salary trends since 1952.

Information was compiled on the basis of questionnaires returned by members of NSPE. Numerous charts and tables show earnings according to geographic distribution of the respondents, year of entry into the profession, branch of engineering, and kind of work. Also included are income differences between engineers in industry and other fields of employment.

ASTM Proceedings, 1956. *1498 pages, 6 by 9 in., clothbound; published by and available from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $12.00 per copy.*

This edition of Proceedings records accomplishments of the American Society for Testing Materials for the year 1956. It includes technical reports and papers, and covers 32 technical sessions of the 59th Annual Meeting.

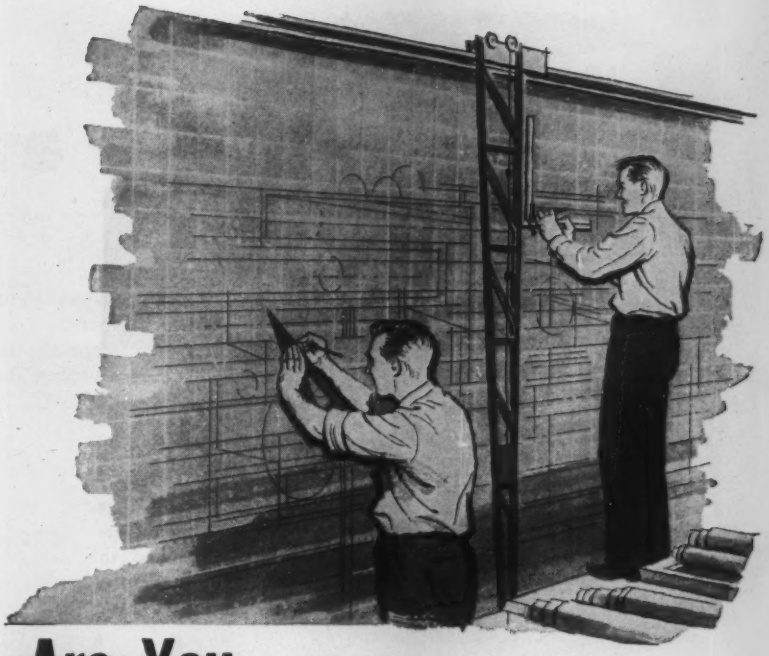
Table of contents and subject and author indexes cover all papers and reports published by the Society during the current year and, in addition to those appearing in Proceedings, include those accepted for publication in the ASTM Bulletin or in Special Technical Publications. A list of the Special Technical Publications published by the Society in 1956 is included.

Manufacturers' Publications

Procedure Handbook of Arc Welding Design and Practice. *1262 pages, 6 by 9 in., clothbound; published by and available from the Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio; $3.00 per copy.*

This book presents revised material on all phases of arc welding. Eight major sections include arc welding history and processes, techniques and costs for welding steel, weldability of metals, basic design, machinery design with arc-welded construction, applications and reference data, and numerous conversion tables.

Material has been rearranged in sequence and paging, and special charts and nomograms are included to aid calculations. New equip-



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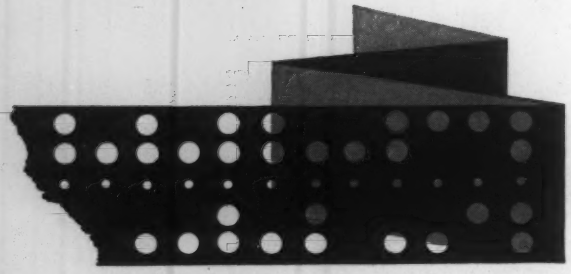

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Engineering Data for Selection and Design of RM Poly-V Drives, No. 10. 112 *pages,* 8½ *by* 11 *in., paperbound; published by and available from Raybestos-Manhattan Inc., Passaic, N. J;* $1.00 *per copy.*

This book contains complete design information for application of Poly-V Drives, single belts with a series of parallel V-ribs. Included are design data sheets; drive tables of speed ratios, ratios, sheave pitch diameter, motor speed and power requirements; service factors; limitations of application; and stock and nonstock sizes.

Parker O-Ring Handbook. 9 *sections,* 8½ *by* 11 *in., paperbound; available on letterhead request from Rubber Products Div., Parker Appliance Co.,* 17325 *Euclid Ave., Cleveland* 12, *Ohio.*

Data in this handbook have been compiled for both experienced designers and those having limited O-ring experience. The handbook is intended as an aid in solving problems in O-ring seal checking, analysis, and application in mechanics and pneumatics.

Major sections include seal characteristics, operation, definitions, selection, mensuration formulas, gland design, installation, lubrication, static and dynamic application, military specifications, design charts, and standard sizes.

Jet-Age Lubricants. 31 *pages,* 8½ *by* 11 *in., paperbound; available from Jet-Age Lubrication, Industrial Service Dept., Lehigh Chemical Co., Chestertown, Md.;* $1.00 *per copy.*

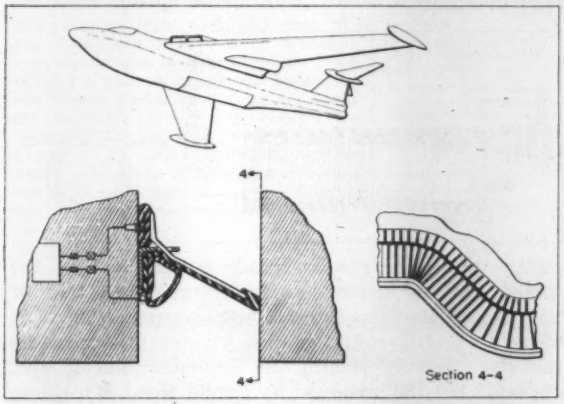
This book presents specific properties of lubricants for various applications and defines these properties in terms of illustrated standard ASTM tests. A special section on U. S. Government specifications and their significance in application is included.

NOTEWORTHY

Patents

Static-Seal Assembly

Curved or irregular door-edge openings are made watertight by a flexible seal assembly that withstands pressure differentials as high as 100 psi. Comprising an elastic membrane supported by closely spaced metal fingers, the seal is extended or retracted by inflation of integral rubber tubes. Application of external pressure reinforces the sealing action of the assembly. Installation shown here is for stores door in seaplane hull. *Patent 2,792,599 assigned to Glenn L. Martin Co. by Gottfried K. Gantschnigg and Herbert H. Buschers.*



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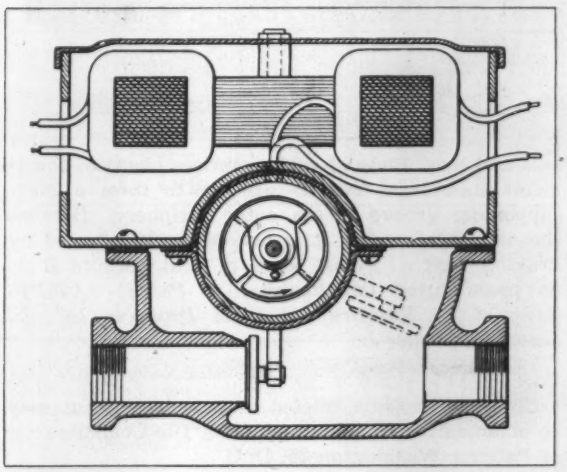

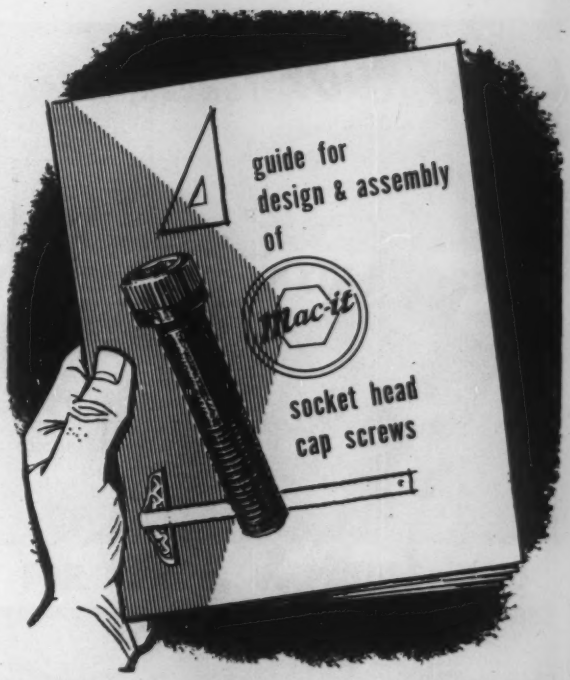

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MAC-IT hex socket alloy cap & set SCREWS

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Hydraulic work feed apparatus	(Leakproof) ... as versus spool valves which cause overdemand on hydraulic system	Positive shut off of internal port to port leakage and of course, no external leakage
Machine tool chucking & clamping	Maintaining safe holding pressure (leakproof)	Saving auxiliary equipment such as pilot operated check valves
Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
Solenoid controlled hydraulic system on machine you build	Better performance Lower manufacturing costs Reduce service problems	Shear-Seal valves have full flow, are leakproof, not sensitive to dirt Low priced, less auxiliary equipment and labor cost. Valves don't stick, saving coil burn-out; stay leakproof indefinitely, seals are wear compensating

BARKSDALE VALVES

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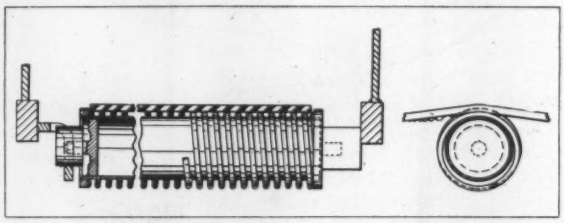
Noteworthy Patents

against fluid pressures tending to hold it closed is facilitated. Because the air gap in the valve magnetic circuit is never completely closed, sticking or hangup is eliminated. Time interval for pickup or drop out is also substantially constant. Typical valve application is in control of gas heater fuel gases. *Patent* 2,800,614 *assigned to Basco Inc. by John H. Thornbury and Russell B. Mathews.*

Self-Cleaning Pulley

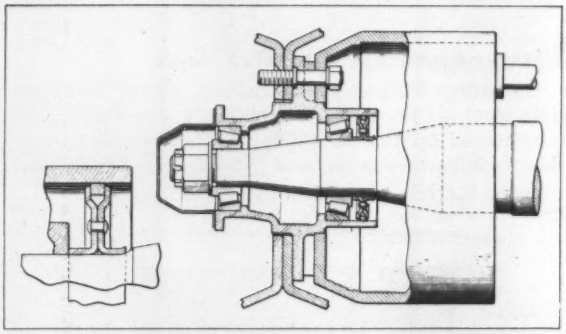
Sticky clay, dirt, or similar materials are prevented from building up on a self-cleaning conveyor-belt idler pulley by a loose-fitting helical spring. Retained



on the pulley or roller surface by end collars, the spring has an inside diameter larger than that of the roller. Radial clearance allows spring to move away from the roller surface on the side opposite the belt, thereby flaking off accumulations of dirt. *Patent* 2,801,733 *assigned to Euclid Road Machinery Co. by Lawrence L. Evert.*

Floating-Ring Seal

Designed for severe-duty service, such as logging-trailer wheel assemblies, a low-cost radial-type seal utilizes a split metal ring to form a seal between



axle and hub. Body of seal comprises identical sheet-metal stampings riveted together to form a ring-supporting groove at the outer periphery. Because the unit is all metal, it is not adversely affected by braking heat. Flange bore of seal permits it to be press fitted on the shaft. *Patent* 2,746,776 *assigned to Kay-Brunner Steel Products Inc. by Joseph F. Bruner Jr.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

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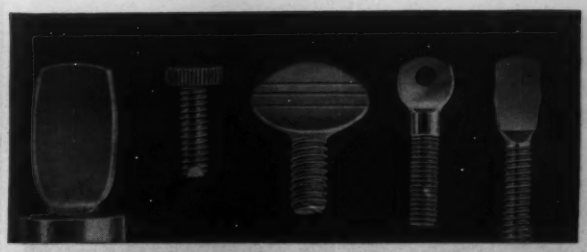

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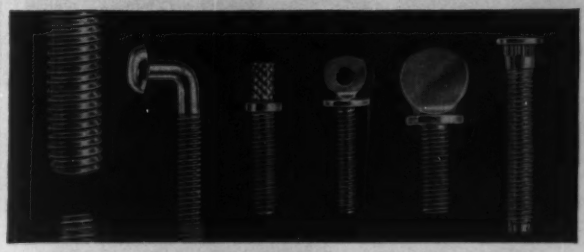

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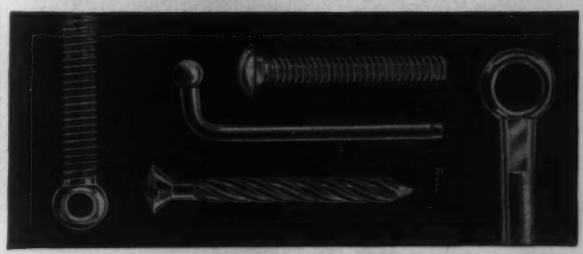

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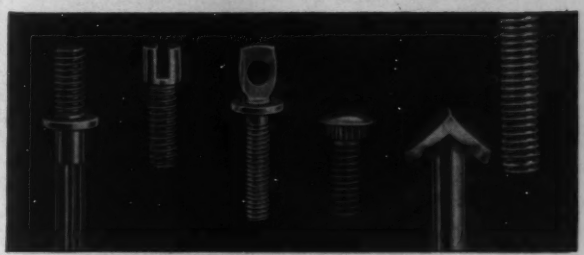

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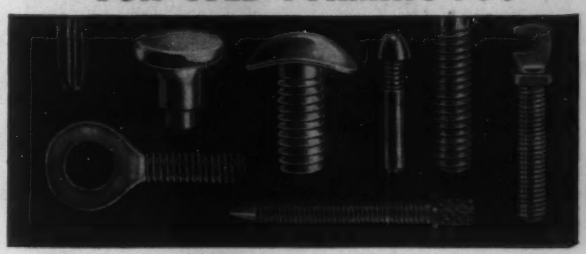

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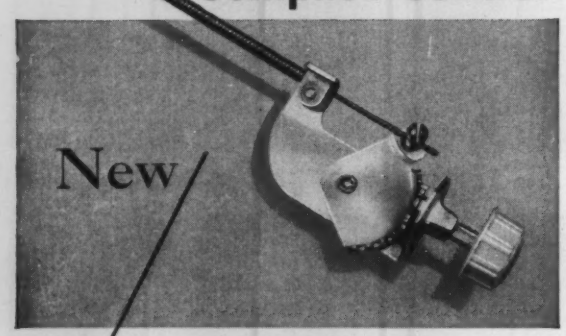

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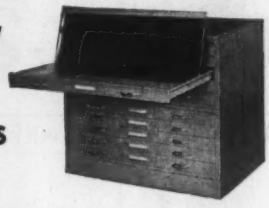

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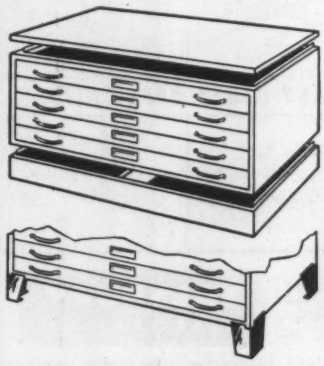

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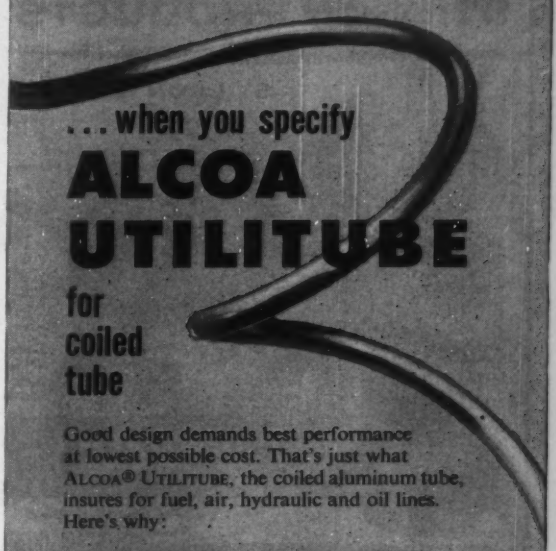

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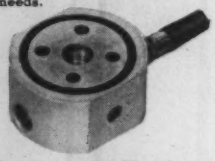

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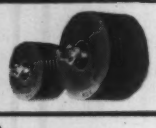

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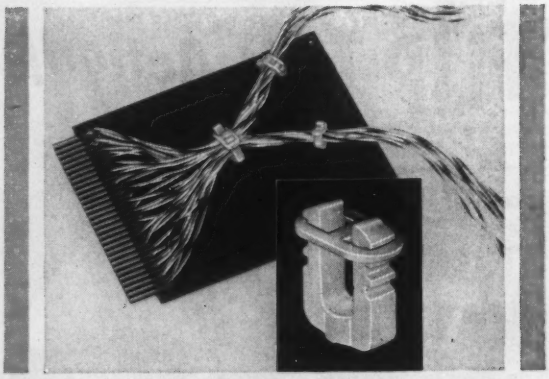

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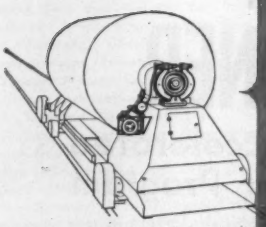

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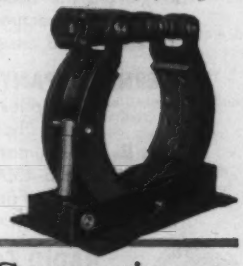

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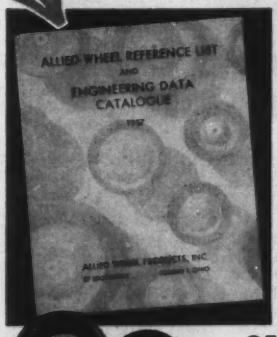

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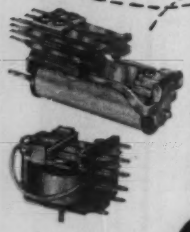

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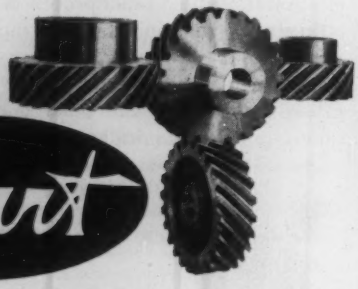

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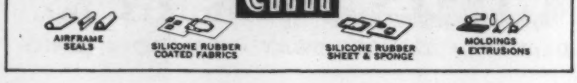

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Circle 597 on page 19

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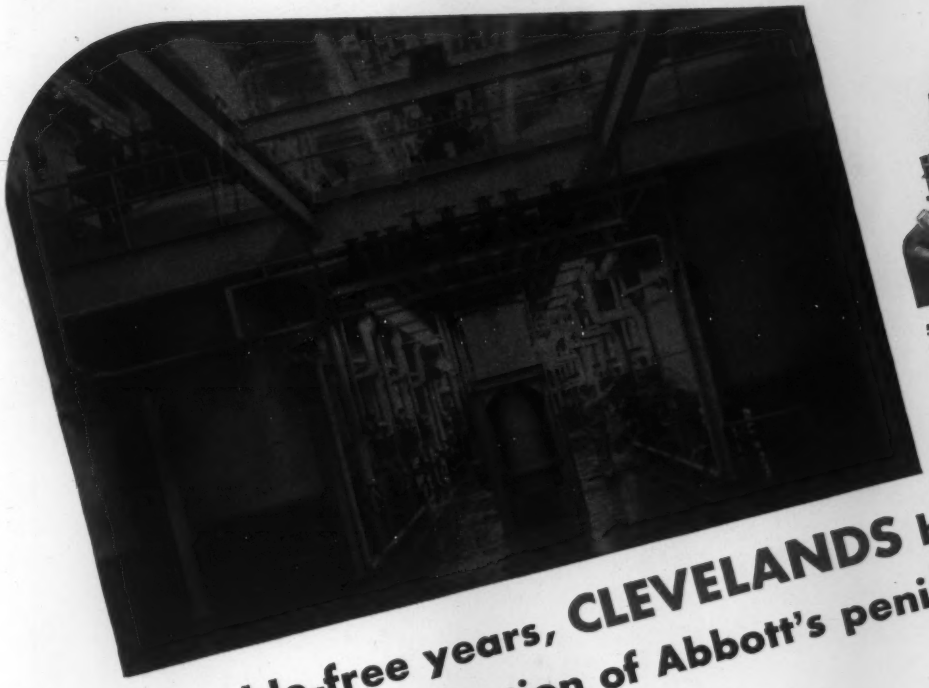

5,000 gallon fermenter with Cleveland horizontal unit mounted above it. At left is the fermentation room, with battery of 12 steel tanks, at Abbott Laboratories, North Chicago, Illinois.

For 10 trouble-free years, CLEVELANDS have served in mass production of Abbott's penicillin

CONTINUOUS, uniform agitation of each batch is essential to proper processing of penicillin and other antibiotics. To insure uninterrupted, trouble-free operation at this leading pharmaceutical plant, Cleveland Worm Gear Speed Reducers were installed over ten years ago to drive the turbine impellers of a battery of 5,000 gallon fermenters.

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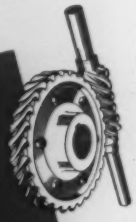

CLEVELAND
Worm Gear
Speed Reducers

Circle 402 on page 19

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CUTLER-HAMMER
MOTOR CONTROL
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The Mark of Better Machines

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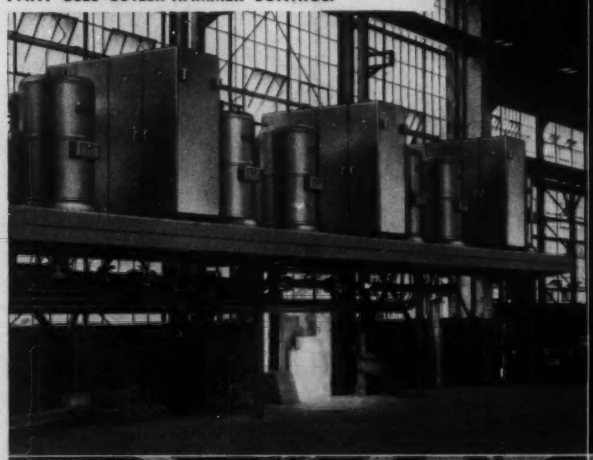

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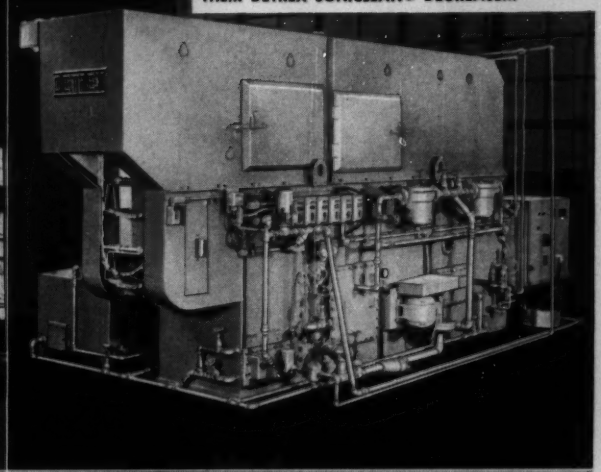
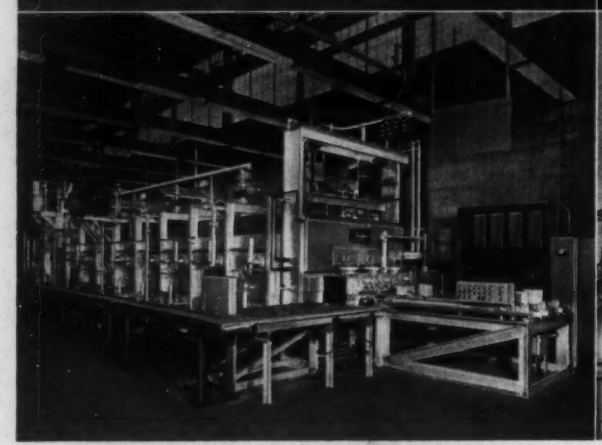
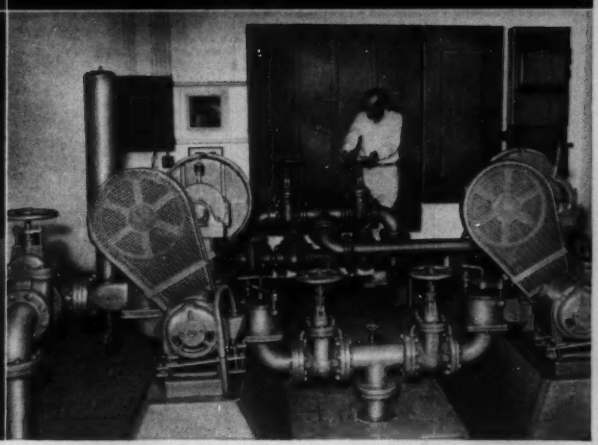




THE FULLY AUTOMATIC PUSHER TYPE CARBURIZING HEAT TREATMENT FURNACE MANUFACTURED BY THE SPECIAL FURNACE DIVISION OF THE SURFACE COMBUSTION CORP. IS EQUIPPED WITH CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND HEAVY DUTY OIL-TIGHT PUSHBUTTONS.



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